FAULT TOLERANCE AND CLUSTERING ALGORITHM FOR WIRELESS SENSOR NETWORKS

DISSERTATION-II

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BY

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CERTIFICATE

This is to certify that **ISHANT KUMAR SHARMA** has completed M.Tech dissertation-II titled **FAULT TOLERANCE AND CLUSTERING ALGORITHM FOR WIRELESS SENSOR NETWORKS** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation has ever been submitted for any other degree or diploma.

The dissertation-II is fit for the submission and the partial fulfillment of the conditions for the award of M.Tech ELECTRONICS & COMMUNICATION Engineering.

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DECLARATION

I hereby declare that the Dissertation-II entitled, **FAULT TOLERANCE AND CLUSTERING ALGORITHM FOR WIRELESS SENSOR NETWORKS** submitted for the M.Tech Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

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ABSTRACT

Currently, the wireless sensor network is facing four major issues namely power management, localization, routing and deployment techniques. Out of these in power management, energy conservation and coverage efficiency are the main issues. Clustering is an approach which helps to preserve the overall communications between the sensor nodes and cluster heads or Clustering method is an energy efficient technique which fundamentally used to reduce the total energy utilization of wireless sensor networks but in a cluster based WSN, cluster heads (CHs) consume more energy power due to extra work consignment while collecting data, data aggregation and also while they communicate to base station. Therefore, proper cluster formation is very challenging in WSN by considering the energy consumption of the Cluster Heads and sensor nodes. In my report, we proposed an efficient algorithm which improves the current clustering based DFCA algorithm which works on both two major issues fault tolerant and cluster formation also helps in improvement of cluster from unexpected breakdown of cluster head at any round. An alternative cluster head (back up node) is deploy with all the clusters which activate when they received a HELP message from member sensor nodes whenever the member sensor nodes do not capable to arrive at the cluster head.

But everything comes with a disadvantage in my research work, improved some disadvantages of DFCA as per at the beginning there is no requirement of backup set so in my work I removed the backup set at a beginning phase or first rounds we implemented a algorithm in which uncovered node is nearest to CH will first collects all the other member uncovered nodes then it will be forward to their respective CH. And on the basis of sensor node die a threshold value will be given in algorithm when number of sensor node die rate is increases that threshold level then the backup set will activated which collects all uncovered nodes and forward them to their respective cluster head.

LIST OF FIGURES

LIST OF ABBREVIATIONS

ALERT	Anonymous Location-Based Efficient Routing Protocol
BS	Base station
BS	Backup set
CH	Cluster Head
CO	Covered set
CN	Covered node
CPU	Central Processing Unit
DOS	Denial of Service
MANET	Mobile Ad hoc Network
PRNET	Packet Radio Network
SN	Sensor Node
QOS	Quality of Connection
WLAN	Wireless Local Area Network
WSN	Wireless Sensor Network

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Chapter 1

Introduction

1.1 OVERVIEW OF WIRELESS SENSOR NETWORK

Wireless sensor network comprises of enormous amount of sensor nodes which have the capacity of sense or observing the surroundings like climate determining which perform the fundamental count interface by means of one another during remote medium. Normally nodes are measured to be motionless yet preferably that is impractical a few application similar to environment screen, investigate and free, surroundings checking and wellbeing check consideration bolster the versatility of sensor nodes. The nodes can likewise shift from their area underneath the control of air, water and mental tap. Because of constrained energy in every component of WSN, the systems do not effort for drawn out stretch of moment. The bunch base methodology of steering be thought to be present an effective method for directing to spare battery control in remote sensor system. Contrasted and the conventional Ad hoc systems, the vitality of every sensor hub is constrained in remote sensor systems [3]. Numerous outline challenges that emerge in sensor systems are because of the restricted assets they contain and their sending at some stage in unfriendly environment. Sensor nodes be conveyed inside situations wherever it is unrealistic in favor of people toward screen them. The uncovered nodes could influence the proficiency of numerous armed and common application, for example, aim ground imaging, appropriated figuring, strategic observation, stock control, catastrophe administration and distinguishing encompassing conditions. A few applications oblige sensors toward be there little in size and comprise small communication reaches on the way to decrease the possibilities of recognition. These amount imperatives create additional requirements on CPU pace, measure of memory, RF data transfer capacity and battery lifetime. Thus, productive correspondence systems are fundamental for expanding the lifetime and nature of information gathering and diminishing the correspondence inertness of such remote gadgets. Not like the mobile ad hoc networks, sensor nodes are immobile for the whole phase of their life span. Although the sensor nodes are permanent, still the topology of the system can modify. Whenever the nodes are low on activity, they can go to stationary snooze state to protect energy. As soon as some nodes run out of sequence power and die, innovative nodes might be additional toward the network. Even though all nodes are firstly prepared with resembling energy, some

nodes may occurrence advanced doings because of area they are positioned in. An essential belonging of sensor networks is the require of the sensors to consistently flow the information to the base station contained by a time period that allow the consumer to take action to the information in a sensible manner, since out of day information is of no apply and may direct to fatal outcome. One more critical ascribe be the versatility to the modify in system dimension and topology. Wireless network Sensor systems are extremely thick and moderate when contrasted with versatile specially appointed and wired systems. This emerges starting the way so as to the sensing reach is lesser than the correspondence extends and after this more nodes are obliged toward accomplish enough sense scope. Sensor nodes are obliged to be impervious to disappointments and assaults. Data steering is an extremely difficult undertaking in Distributed Sensor Networks because of the unchallengeable qualities that distinguish these systems from dissimilar remote or spontaneous system. The sensor nodes sent in a specially appointed way need to act naturally arranging as this sort of sending obliges framework to frame associations and adapt to the resultant nodal dispersion. Another imperative issue while outlining sensor systems is to sensor systems are purpose particular. Thus the purpose situation requests the convention outline in a sensor system. Likewise, the information gathered by sensor nodes is regularly excess and needs to be misused by steering conventions to enhance vitality and data transfer capacity usage. The proposed steering conventions for sensor systems ought to consider all the above issues for it to be extremely effective.

The calculations created need to be exceptionally vitality effective, adaptable and build the life of the system simultaneously. The multitudes of outline difficulties forced on Sensor Networks have a tendency to be truly mind boggling and ordinarily challenge the logical routines that are very compelling for conventional systems. At current phase of innovation not very many Sensor Networks have started to be. Albeit there are numerous unsolved exploration issues in this space, genuine organization and learning is infeasible. The main functional exchange to learn Sensor Networks is throughout reenactment, which can give improved knowledge to conduct and execution of different calculations and conventions. In the event that the node is not ready to speak with other through direct connection, i.e. they are out of scope zone of one another, information parcels can be sent to the another sensor hub by utilizing sensor nodes as a part of between the group. This methodology is elude as multi-trusting [4]. All sensor nodes

work agreeably to serve the appeals. Subsequently here is no requirement for prerequisite of secured environment or the predefined foundation to send the system segments. WSN gives adaptability of including sensor nodes and evacuating the sensor nodes according to the necessity of framework execution. However, this sensation offers ascend to numerous progressions in a system to manage in the system, for example, redesigning the separation, or the system tree, CH to base station separation and so on. In a WSN the sensor nodes that assembles the information data is known as a sink, which advances are known as source.

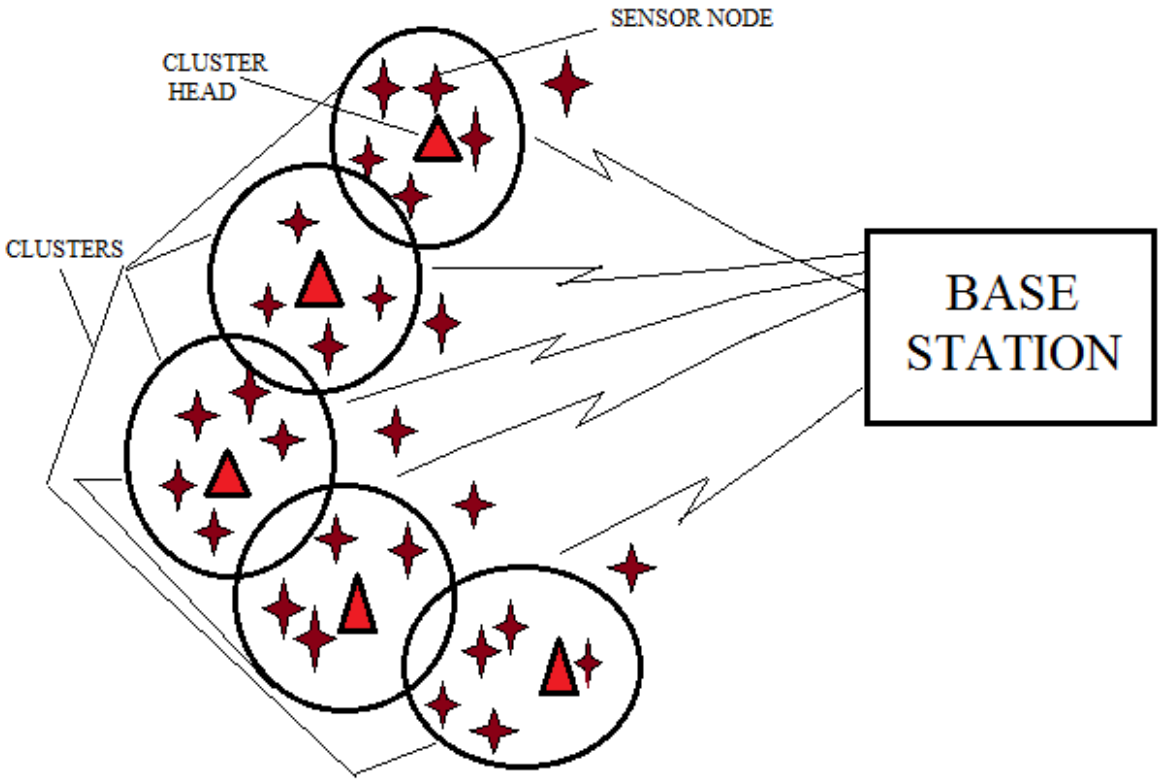

Figure 1.1 A wireless sensor network model

The sink may be connected to the other systems through internet where the information can be utilized on the basis of time [4]. The sensor nodes are small and inexpensive so they are deployed in large number. The resources are limited because sensor nodes are small, limited energy, bandwidth, and computational speed. The battery is limited so the life time of sensor nodes are also limited and the lifetime of sensor network is limited. Thus energy efficiency is a major issue for sensor networks [5]. There are two types of WSNs based on the deployment of network components one is referred as structured and another one is refereed as free or random basis. A random deployment based WSN is defined as which contain a group of

large number of sensor nodes. Sensor nodes might be alive placed randomly into the field. Once located, the network is no more examined or checking regularly the status of network to perform monitoring and sensing functions or the network maintenance because there are so many nodes and not aware of user system but in case of structured WSN which works exactly opposite to unstructured WSN, sensor nodes be deploy statically in the cluster. The main advantage of a static deployment based network in comparison with unstructured network is that smaller amount of nodes which can be deploying in static manner with lesser network preservation and less running cost. In static the nodes be placed in proper manner or at a proper location so there is less threat of uncovered region but in case of unstructured the nodes are deploy randomly so there is most uncovered region present. Unlike traditional wireless sensor networks, some network have it's possess plan parameters with system supply constraint. Basically supply constraint include a most short communication range, less bandwidth, limited amount of energy, and limited processing and storage capacity in each node and if we talk about the supply constraint be mostly purpose dependent and are base on the surroundings monitoring. The atmosphere plays a most important role in shaping the deployment scheme, the dimension of the network and the topology used in the system. The network dimension varies with the atmosphere monitoring. In case of indoor environments, lesser sensor nodes are necessary to build up a system in a less gap whereas outdoor environments might need maximum amount of nodes to cover up a large region. Random employment or the ad hoc employment is chosen over static employment after the atmosphere is not easily operated by individuals or when the network is collected more sensor nodes. [6]

1.1.1 **Background of Sensor Network Technology**

Researchers observe WSNs as an ‘‘electrifying emerging field of extremely network stems of less-power wireless sensor nodes with a small quantity of memory management and big network for regular sense of the surroundings or environment monitoring’’ [7]. Sensors in WSN have many purposes, functions, and capabilities. Examples of early-deployment sensor networks are Air traffic control which is controlled by the radar networks and the most important which serves electricity to whole country i.e. the nationwide electrical control grid and national climate forecast stations deployed over a standard topology net all of these used

a mainly similar system which basically uses a communication protocols and a specialized software computers and are very costly in terms of simple traditional systems. Less costly Wireless Sensor Networks are currently being designed for some special application like in healthcare, substantial security, and exchange. A very new technology in sensor networks the Earthquake-oriented sensors are deployed inside the buildings which can place possible survivors and can assist in structural harm, and also the tsunami-alerting sensors are helpful designed for earlier examination of tsunami threat. Sensors also serve as a most important application in the field of reconnaissance and surveillance purposes.

Power efficiency in WSN is done in 3 conducts:

- Operation in Low duty cycle.
- Reduce transmission time
- Implementation of Multi hop networking

1.1.2 Types of Sensor Networks

There are five types of WSNs: terrestrial WSN, underground WSN, underwater WSN, multi-media WSN, and mobile WSN.

- **Terrestrial WSNs**

  They commonly comprise of hundreds to a great many cheap remote sensor nodes conveyed in a given region, either in an impromptu or in a preplanned way. In specially appointed organization, sensor nodes can be dropped from a plane and haphazardly set into the target zone. In preplanned organization, there is framework situation, ideal arrangement, 2 -d and 3-d position models. In a physical WSN, dependable correspondence in a thick situation is critical. Physical sensor nodes must have the capacity to successfully impart information back to the base station. While battery force is restricted and may not be rechargeable, physical sensor nodes however can be furnished with an auxiliary force source, for example, sun based cells. Regardless, it is imperative for sensor nodes to moderate vitality. For a physical WSN, vitality can be saved with multi -bounce ideal steering, short transmission range, in-system information collection, taking out information repetition, minimizing postpones, and utilizing low obligation cycle operations.

- **Underground WSNs**

  They comprise of various sensor nodes covered underground or in a cavern or mine used to screen underground conditions. Extra sink nodes are situated over the ground to transfer data from the sensor nodes to the base station. An underground WSN is more costly than a physical WSN as far as hardware, arrangement, and upkeep. Underground sensor nodes are extravagant in light of the fact that fitting gear parts must be chosen to guarantee dependable correspondence through soil, shakes, water, and other mineral substance. The underground environment makes remote correspondence a test because of sign misfortunes and elevated amounts of weakening. Not at all like physical WSNs, the sending of an underground WSN obliges cautious arranging and vitality and expense contemplations. Vitality is a critical concern in underground WSNs. Like physical WSN, underground sensor nodes are outfitted with a constrained battery force and once conveyed into the ground, it is hard to revive or supplant a sensor hub's battery. As some time recently, a key target is to save vitality with a specific end goal to expand the lifetime of system.

- **Underwater WSNs**

  They comprise of various sensor nodes sent submerged. As inverse to physical WSNs, submerged sensor nodes are more extravagant and less sensor nodes are sent. Self-ruling submerged vehicles are utilized for investigation or social occasion information from sensor nodes. Contrasted with a thick arrangement of sensor nodes in a physical WSN, an inadequate organization of sensor nodes is put submerged. A test in submerged correspondence is the restricted transfer speed. Another test is sensor hub disappointment because of ecological conditions. Submerged sensor nodes must have the capacity to outline toward oneself and adjust to unforgiving sea environment. Submerged sensor nodes are outfitted with a restricted battery which can't be supplanted or revived. The issue of vitality protection for submerged WSNs includes creating proficient submerged correspondence and systems administration strategies.

- **Multi-media WSNs**

  They have been proposed to empower checking and following of occasions as mixed media, for example, feature, sound, and imaging. Multi-media WSNs comprise of number of ease sensor nodes outfitted with cams and receivers. These sensor nodes interconnect with one another over a remote association for information recovery and methodology. Multi-media sensor nodes are sent statically into the earth to ensure scope. Difficulties in multi-media WSN incorporate high data transmission request, high vitality utilization and nature of administration provisioning, information transforming. Multi-media substance, for example, a feature stream obliges high data transmission in place for the substance to be conveyed. Therefore, high information rate prompts high vitality utilization. Transmission procedures that bolster high data transfer capacity and low vitality utilization must be created.

- **Mobile WSNs**

  They comprise of an accumulation of sensor nodes that can proceed onward their own and cooperate with the physical environment. Versatile nodes have the capacity sense, process, and convey like static nodes. A key distinction is portable nodes can reposition and sort out itself in the system. A portable WSN can begin off with some starting arrangement and nodes can then spread out to accumulate data. Data accumulated by a versatile hub can be imparted to another portable hub when they are inside scope of one another. Another key distinction is information circulation. In a static WSN, information can be circulated utilizing settled steering or flooding while element directing is utilized as a part of a versatile WSN. Difficulties in versatile WSN incorporate organization, restriction, relationship toward oneself, route and control, scope, vitality, upkeep, and information process.

1.1.3 Advantages of Wireless Sensor Networks

There are some merits of wireless sensor network.

- **Simplicity of Deployment**

  The wireless sensor networks are able to be deploying at the interested site with no any pre association. Thus saving the installation price and rising the flexibility

- **Unlimited range**

  One vast wired sensor can be replaced by lots of small wireless sensor networks for the same price. One sensor is able to sense only tiny area but network of small sensors can be dispersed over a wider area

- **Error tolerant**

  Since sensor networks are mostly unattended, they should have error tolerant ability. If one sensor fails then it doesn't have an effect on the network process much because there are additional nodes also collect the same information. The data correctness may be reduced.

- **Mobility**

  Since wireless sensors are equipped with battery, they have limited mobility. Thus if a region becomes unmonitored the nodes can re arrange themselves to allocate consistently which means that these nodes can be complete to shift towards the vicinity of attention.

1.1.4 Applications of Sensor Networks

Wireless sensor networks have been used in the field of some high-end applications such as security systems as well as many military applications like weapon etc. Most recently the interest has been focusing on biological networks and chemical sensors for security based applications or the defense related applications and also in the field of direct consumer applications like manufacturing automation, electronic shopping etc. Existing and important applications of sensor networks includes environment monitoring, security, air traffic control, military or defense based applications, surveillance based applications, video stream surveillance, industry based applications like control process, management of inventory, robotics based application, weather sensing or environment monitoring, line of control or a national border monitoring comes under defense applications [11]. A short list of applications is as follows:

- **Military applications**

  - Monitoring enemy forces.
  - Monitoring friendly forces and equipment.

- Battlefield based or Military surveillance.
- Targeting the enemy location.
- War damage assessment.
- Chemical like nuclear attack detection.

➢ **1.1.4.2 Environmental applications**

- Microclimates.
- Agriculture Research.
- Forest fire detection.
- Flood detection.

➢ **Health applications**

- Remote monitoring of physiological (bone damage) data.
- Tracking and monitoring list of present specialized doctors and also a patients recovery report inside a hospital.
- Drug present in hospital or their administration.
- Elderly assistance.

➢ **1.1.4.4 Home applications**

- Home automation.
- Instrumented environment.
- Automated meter reading.

1.2 Introduction to clustering

Clustering procedure is a vitality productive strategy which fundamentally used to reduce the aggregate vitality utilization of remote sensor systems. If there should be an occurrence of gathering based construction the nodes are isolated in distinctive gatherings and in a gathering framework there is one gathering pioneer called group head. Every sensor hub has a place with one and only gathering (group). A cluster based remote sensor system has enormous points of interest like it diminishes high vitality utilization, keeps up correspondence data transmission and enhances general framework execution of the entire

system. However every framework accompanies a negative marks in it, if there should be an occurrence of cluster approach, a cluster head comes up short because of some additional work burden while getting information sent by the part sensor nodes though in numerous sensor arranges the cluster heads are generally chosen from the typical sensor nodes without as certain there vitality this reason to group that it kicks the container rapidly because of additional effort load. In prior period, scientists utilized a number of uncovered nodes by more vitality these called as relocate nodes which functions as similar as cluster heads. on the other hand these are additionally battery based so the life span problem is most imperative is instance of these sorts of system so the best possible network sensor node to cluster head by taking into consideration the residual vitality of the CH. Sensor nodes and group leader heads are generally fizzles because of group head disappointment or because of battery consumption. Significant issue in grouping methodology is disappointment of group head which harms entire framework in light of the fact that the gathered sensor nodes are associated with a specific bunch head and on occasion when bunch head fizzle the sensor nodes of that specific bunch is additionally gets to be inert despite the fact that at disappointment time some of them have staying remaining vitality. Hence, an adaptation to internal failure is additionally real issue for long run operation of remote sensor system. Naturally, grouping sensor nodes into clusters mostly used by the researchers to improve the above scalability objective and for achieving high energy efficiency and prolong network long run operation on large networks environments, in a order that data collection and forward communicates the collected data are possible, this process by process delivery saves energy. In case of hierarchical network structure each cluster has its own group commander, which is also known as the cluster head (CH) and usually performs main functions collecting the sensor nodes and forward them to base station. Proper cluster formation process divided into a two-level process at which place the gateway nodes form the higher level and the member sensor nodes form the lower. The sensor nodes which are collected or communicated with CH periodically transmit their data to the corresponding Cluster head nodes. The CH nodes collected the data from the sensor nodes and transmit all the data to the base station (BS). The common solution for balance the energy consumption in all the network sensor nodes is too used to periodically re-elect new CHs in each cluster in case of sudden failure or cluster head. The BS is the data processing point for the data received from

the sensor nodes, and where the data is accessed by the end user. It is generally considered fixed and at a far distance from the sensor nodes. The CH nodes actually act as gateways between the sensor nodes and the BS. The function of each CH, is to perform common functions for all the nodes in the cluster, like aggregating the data before sending it to the BS. In some way, the CH is the sink for the cluster nodes, and the BS is the sink for the CHs. Moreover, this structure formed between the sensor nodes, the sink (CH), and the BS can be replicated as many times as it is needed, creating multiple layers of the hierarchical structure WSN [22].

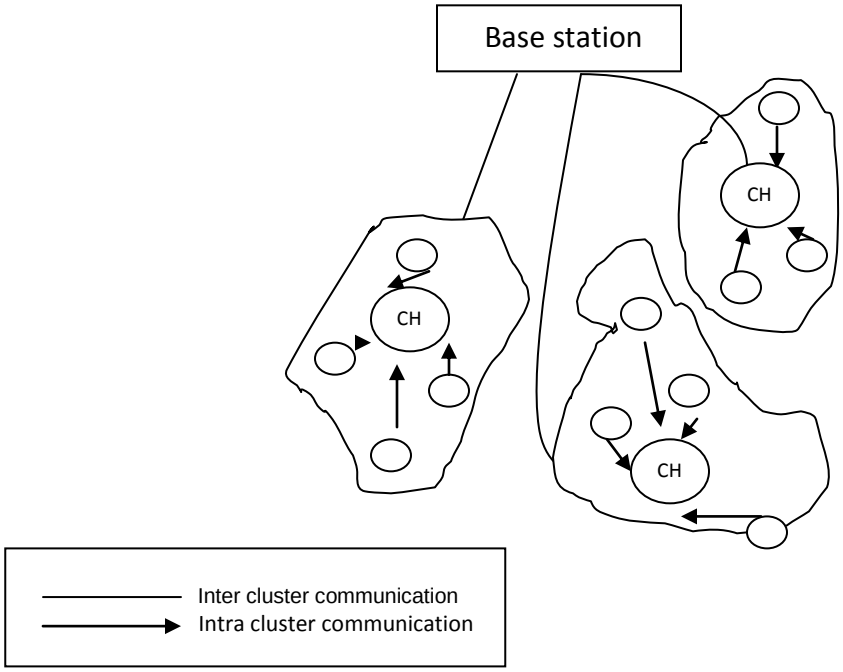

Figure 1.2 Data communication in a clustered network.

1.2.1 Main Objectives and Design Challenges of Clustering

As mentioned above, hierarchical clustering in Wireless sensor network improves the overall system scalability, lifetime, and energy efficiency or in other words Hierarchical routing [4] is a more efficient way to consume lower energy within a cluster for performing a collection of data and forwards the data for decreases transmission messages at one time to the Base station. A single-tier network can cause the cluster head failure with the increase in sensors density and work overload. Such overload might cause interruption in overall communication and cluster head failure. In addition, the single-tier architecture of sensor network is not

scalable for a larger set of sensors covering a big area of interest because the sensors are typically not capable for long run communication. Hierarchical clustering is particularly useful for applications that require scalability about hundreds or thousands of nodes. Here Scalability means the need for load balancing and efficient resource utilization. Applications which requires more data aggregation (e.g., computing the maximum detected radiation in a large area).

In addition to supporting network scalability and decreasing energy consumption of wireless sensor network through the data aggregation, clustering has numerous other secondary advantages; it can localize the route setup within the cluster. It can also conserve communication bandwidth because it limits the scope of inter cluster communications to CHs and avoids redundant exchange of message packets among sensor nodes. Moreover, clustering can stabilize the whole network topology at the level of sensors and thus cuts on topology maintenance overhead. Sensors would care only for connecting with their respective CHs and would not be much affected by changes at the level of inter-CH tier or within a cluster communication. The Cluster Head can also implement optimized management strategies to further enhance the network operation (long run operation) and prolong the battery life (energy efficient) of the individual sensors. A Cluster Head can schedule activities in the cluster so that the nodes can switch to the lower sleep mode and reduce the rate of energy consumption. Moreover, sensors can be engaged into a round order and the time for their transmission and reception can be determined so that the sensors failure are avoided, redundancy in coverage will be limited, and medium access collision is prevented. Wireless sensor network also present several particular challenges in terms of design and implementation of sensor network. Similar challenges and design goals have also been faced earlier in the field of mobile ad hoc networks (MANETs), and a lot of related ideas (considering clustering protocols etc.) have been taken from that field. In Wireless Sensor network the limited capabilities (battery power, transmission range, processing hardware and memory used, etc.) of the sensor nodes combined with the special location-based conditions met (not easily accessed in order recharge the batteries or replace the entire sensors) make the energy efficiency and the scalability factors even more crucial. The ability of a WSN clustering scheme to preserve secure communication is ever more important when considering these networks for military applications. Slotted transmission schemes such as

TDMA allow nodes to regularly schedule the sleep intervals when system is not in used to minimize energy used. Such schemes require corresponding or regular based synchronization mechanisms and the efficiency of this mechanisms must be considered. Data aggregation: Because this process makes energy optimization possible it remains a fundamental design challenge in many sensor network schemes nowadays.

1.2.2 Types of clustering in wireless sensor network

1.2.2.1 Hierarchical clustering

Hierarchical clustering is used when the network components such as sensor nodes are located near to the other components. These algorithms basically used to connect "network components" like connection of sensor node with cluster head to form "clusters" based on their distance or residual energy and other parameters. Cluster can be described by implementing the standard distance formula for needed to connect parts of the cluster like sensor nodes and cluster heads with their particular base station. Depending upon the distances, clusters are formed, which are named as "hierarchical clustering". These algorithm works on a hierarchy of clusters that communicate with each other. Connectivity based clustering is a collection of methods that differ by the distances which are computed by implementing the distance formula like Euclidean distance methods. Not only the usual choice of distance formulas, the user also needs to works on the linkage functions (since a cluster consists of multiple things like sensors, there are multiple sensor nodes to compute the distance from base station to cluster head or cluster head to sensor nodes) to use. Types for that systems choices are basically known as single-linkage clustering (the minimum of nodes distances), complete linkage clustering (the maximum of node distances) or UPGMA.

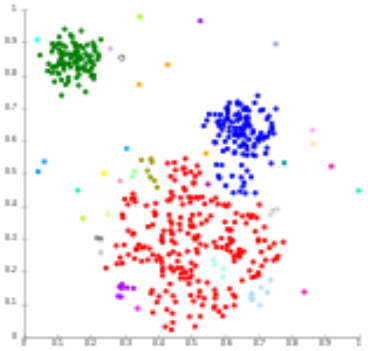

Figure 1.3 Graph shows the Single-linkage on Gaussian data [31].

1.2.2.2 Centroid-based clustering

In centroid-based clustering, clusters are represented by the central vector, which may or may not be a part of the given data set. The number of CHs is fixed to particular variable unit like k, then in that case the clustering is the k-means clustering.

1.2.2.3 Distribution-based clustering

Mostly cluster based statistics is based on distribution models. The Clusters can be defined as collection of sensor nodes and a group leader of that cluster i.e. cluster head belonging most likely to the same distribution system. A more convenient property of this kind of approach is that this will closely resemble to the way by which the artificial data sets are generated and by sampling random objects from a distribution model. The theoretical approach of these methods is more efficient but they suffer from one major problem known as over fitting, unless the ingredients of clusters are put on the system model complexity.

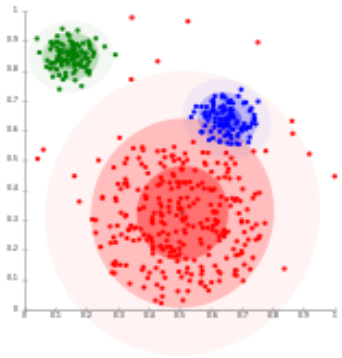

Figure 1.4 Graph shows Gaussian-distributed data. [31]

1.2.2.4 Density-based clustering

In density-based clustering, clusters are defined by the areas of density. The mostly implemented density based clustering method is DBSCAN. The main objective of DBSCAN based on connecting points or connecting the sensor nodes with the cluster head within a certain distance implementing thresholds value. However, it only connects objects of cluster that satisfy a density criterion, [31]. A cluster consists of objects such as cluster head and sensor nodes or objects that are in the range. Another advantage of DBSCAN is that its complexity is very low - it requires only a linear number of range estimation on the basis of database and that will help to discover essentially the same results

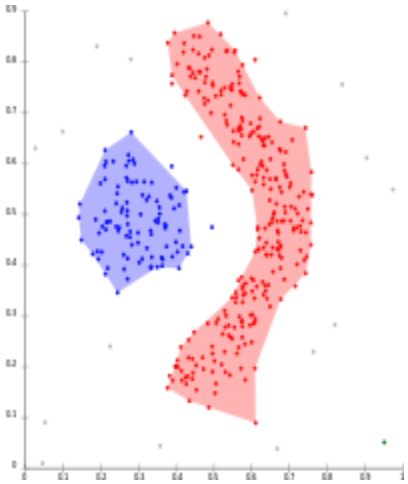

Figure 1.5 Density-based clustering with DBSCAN [31]

1.2.3 Advantages of clustering

- **More Scalability:** In a cluster based WSN system, sensor nodes are divided into a number of clusters on the basis of total number of sensor nodes. The Cluster Heads are responsible for data aggregation from all member neighborhood nodes, information dissemination and also network management, and the Mobile Networks for sensing and information collecting from all the sensor nodes. Clustering topology minimize the routing table for each individual sensor nodes in clusters as compared with a flat topology system.

- **Data Aggregation/Fusion:** The process of aggregating eliminates redundant transmission and provides data to the Base station, is a more convenient technique for WSNs to save energy. The mostly used technique to achieve data aggregation/fusion method is clustering data collection from different sensor nodes, in which each CH bind up the collected data and transmits the whole data to the Base Station form their respective cluster head. Usually cluster heads are formed a structure which transmits aggregated data by implementing multi hopping through other cluster heads which results in energy savings.

- **Less Load:** Since sensor nodes mostly generate redundant data or find the redundancy in the main data, the main criteria of data aggregation or fusion is to combine data from different sources to eliminate redundant data transmissions, and provide a more accurate and multi-dimensional monitoring of the targets. Many clustering routing schemes with fusion capabilities needs a careful selection for proper clustering. In Cluster based network, all cluster members only send data to Cluster Heads, [35] and data aggregation is performed at the all CHs, which helps in reduce transmission data and energy efficient. In addition, the routes are set up within the clusters which will help to decrease the size of the routing table saves at the location of sensor nodes.

- **Less Energy Consumption:** For clustering based routing scheme, data aggregation helps to reduce the transmission data and save energy. In addition, inter-cluster and intra-cluster communications used to reduce the number of sensor nodes that will helps in performing the task of overall or distant communications, thus helps in less energy loss

for the entire sensor network. Moreover, only CHs perform the task of data aggregation or routing of data packets in clustering routing scheme, which helps to save the more energy or make the system more efficient in terms of energy.

- **High Robustness:** Clustering data routing based schemes are makes it more convenient for more controls the network topology and also responds to network changes node increasing, overall mobility of node and sudden failure of cluster head etc. so the whole model network become more robust and more convenient for management of cluster heads and sensor nodes. In order to examine the overall CH responsibility or status, cluster heads are become stationary to all the sensor nodes to recovery of cluster head failure in algorithms.

- **Collision Avoidance**: In case of multi-hop flat model, communication wireless medium is managed by neighbor member sensor nodes, thus this model will leads to low energy efficiency in the usage of main network components. On the other hand, in case of multi-hop clustering model, sensor network is divided into different clusters and the network components communications between the sensor nodes comprise in two modes, i.e., intra-cluster and inter-cluster, which used for the data collection or bind up the whole data and for data transmissions..As a result, the multi-hop clustering model is appropriate for large-scale wireless sensor networks.

- **Latency Reduction**: Whenever a clustering WSN system is used, only cluster heads transmit the data from one cluster to other or form nodes to clusters. [29] The mode of data transmissions in cluster helps avoiding collisions between the sensor nodes. Accordingly latency is reduced.

- **Load Balancing:** It is an essential merit which aims at long run operation of the network. The distribution of sensor nodes (depends on random or manual selection sensor node in a cluster) among all the clusters is usually considered for cluster formation. The cluster heads performs data processing. Equal-sized clusters are adopted to make a prolong network even it causes the exhaustion of energy. Multi-path routing is also used to achieve load balancing.

- **Guarantee of Connectivity:** Nodes transmit data to one or more sinks. The single-hop or multi-hop routing techniques are used to ensure whether the data is reached or not. The connectivity of each node provides information of it. [30] The sensor nodes that are not able to communicate with any other nodes those are isolated. The data of those nodes cannot be transmitted to the base station, but in case of clustering the algorithm guarantees the node to BS and BS to cluster head connectivity.

1.3 Introduction to fault tolerance

Fault tolerance [4] is simply defined, by every exacting round if the cluster head fail because extra work load or any other power efficiency associated matter then it affect complete arrangement or the main cluster to conquer this trouble many approaches are used mostly whenever the system algorithm detect the error on every occasion it does not take delivery of any acknowledgement or respond communication it resolve too detect by associate sensor nodes since at that instance owed to breakdown of cluster head additional associate nodes too stop working.

Fault tolerance is a property that enables a system to operate properly even a system or single or extra faults contained by system. If it's working excellence decrease, the reduce in system performance is comparative to the harshness of the system breakdown.

A fault-tolerant design [5] basically enables a system to operate at a reduced level or a level when the particular sensor node or the cluster head dies. This process is most commonly used in computer systems designed to make more or less operational with a reduction in throughput result or an increase in response time in the event of some partial failure like sensor node failure or the cluster head problem.

In fault-tolerant computer systems, programs are designed to continue for long run operation to overcome the error, instead of switching off the whole system completely. A system with high failure rate will alert system users that a system failure has occurred, even if it will continues to operate with overall communication, so that the failure can be repaired or tolerated at a particular time instance when fault will detected. The system will design in such a way that it reports at the first state, and not allow system to fail and generate reports of failure then. This allows easier recovery of the underlying problem.

1.3.1 Basic Requirements of fault tolerance

The basic characteristics of fault tolerance system require:

1.3.1.1 Failure of system Not at single point – During communication in case if a system experiences a failure of sensor nodes or cluster head, [5] the system must continuously operating during the repair process.

1.3.1.2 Recovery to the weakening object – When a breakdown occurs in a structure then it have to be able to tolerate or recover the breakdown to the failed part. This require the additional algorithm which will active as the fault occurs in a system.

1.3.1.3 Fault recovery to recover propagation of the failure – Some kind of failure may cause the failure of the whole system [5]. For example "rogue transmitter".

1.3.1.4 Reversion modes- During failure of system the availability of reversion mode is much requires in order recovering the whole system property.

Notwithstanding this point, error tolerant frameworks are fundamentally described regarding both the arranged administration blackouts and additionally impromptu administration blackouts. The measures are at the equipment level not just at the application level. The figure of legitimacy is called accessibility of framework and is communicated as rate esteem. For instance, 99% accessibility, Fault-tolerant frameworks are in light of repetition.

1.3.2 Disadvantages of fault tolerance

The advantages of fault tolerance system are obvious terminology like system recovery, long run operation etc. but everything is comes with some kind of demerits in case of fault tolerance system there is also some disadvantages which are as follows:

- **Interference with fault tolerance algorithm in the same component:** In start of every system usually there is no need of fault tolerance algorithm implementation this will cause overlapping with the main system algorithm so to overcome this system should be operated with a part "automatic fault-detection structure".
- **Interference of main algorithm with fault recognition in a different part within a system:** an additional phase of this difficulty is that the error tolerance is in single system

part but it repairs the fault detected in the other component. E.g.: A component 'X' performs similar process based on the output from constituent Y, then error tolerance in X can hide from view a trouble with Y. If there will be delay to change the component X then the system may fail quickly. After examine the system carefully it becomes apparent that the main difficulty is really with the constituent Y and not with component X.

- **Priority of reduction for error correction.** If the operative is already knows about the error and a error-tolerant system tries to decrease the repair cost. If the fault are not correct, this leads toward the breakdown of system.
- **Test difficulty.** For more dangerous fault-tolerant systems, similar to nuclear reactor, then it will become difficult to examine that the backup components are operated properly or not. There can be massive release of radiation and core meltdown due to failure of cooling backup system.
- **Cost.** The fault-tolerant as well as redundant components increases the system cost. It can be a simply financial cost. It also includes other procedures, such as mass. For example spaceships.
- **Low-grade components.** An error-tolerant propose requires using the low-grade components, even this increases the cost. If it will not be done, this will made the system die.

Chapter 2

REVIEW OF LITERATURE

Md Azharuddin Pratyay Kuila Prasanta K. Jana et.al [1] In Cluster based system sensor nodes and cluster heads consume more energy owed to extra work load or else sensing in harsh environment and additionally because of disappointment of cluster heads in this way for proficient clustering calculation or as such for effective group development which equipped for gathering information and perform information accumulation in legitimate way., it is essential to take care about the proper cluster formation and fault tolerance. Basically in this paper author propose an algorithm named as DFCA (a distributed fault tolerant clustering algorithm) which uses a cost function of CH. For putting forth group in defense of sudden disappointment of CH and it gives go down set and go down sensor node which will dynamic amid the cluster head disappointment

Assume a simple wireless sensor network model that basically consists of two types of nodes (1) sensor node and another one (2) CLUSTER HEAD. All the nodes and cluster heads are deploy manually or also randomly into sensing region and they are stationary to each other after deployment. One sensor node join to one cluster head if the cluster head is within the range of node, then it will capable of performing communication and also direct communication with the base station. First all the cluster heads and sensor nodes undergo bootstrapping process, which means unique id is provided to all sensor node and cluster heads then base station broadcast HELLO message to all stations at certain power level and at particular communication range, the message contains the unique id's, residual energy[6] and also the distance[9], after a certain wait if node receives at least one reply of HELLO message then that node will become member of covered set otherwise it will be become member of uncovered set, then sensor node broadcast HELP message and the backup set is activated, thus the sensor nodes which are not covered because of cluster head failure will forwarded to CH or assigned to CH by back up set.

S.Taruna, Sheena Kohli, G N purohit et.al [2] proposes the algorithm which works on the selection of nodes to cluster head on the basis of distance and remaining residual energy in homogenous wireless sensor network. In this they implementing the simple Euclidean distance and the residual energy formula in the proposed algorithm, the results are better than

the previous algorithms and less number of computations are present in proposed algorithm and also equipped for long run operation regarding less number of sensor nodes bites the dust with the increment in number of rounds. Proposed algorithm calculates the transmission energy and receives energy of sensor node and on the basis of Euclidean distance and remaining energy of cluster head and sensor nodes.

Gaurav Gupta and Mohamed Younis et.al [3] presented an approach to cluster uncovered means those nodes which are not in the range of cluster heads in wireless sensors and about few high-energy gateway nodes and balance load among these clusters. Cluster group leader node or a cluster head acts as a leader or manager which handles the sensor nodes and serves connections from sensors to a uncovered sensor nodes. If nodes are not uniformly distributed around the cluster head the clusters formed will be of varied load, which will affect the life and energy consumption of the system. Simulation results show the strength of algorithm consistently balances load among different clusters and performs well in all distributions of sensor nodes.

Gaurav Gupta and Mohamed Younis et.al [4] For the sake of improvements in their previous work in 2003 they presented a new approach which represents High-energy alternative cluster node acts as a centralized manager to connecting the sensors and a cluster head hop count to relay node data from sensors to a uncovered node. Basically they introduced a two phases, proper cluster formation and recovery of cluster from cluster head failure without switching off the whole system or re-clustering the whole system model. Cluster heads mostly failed due to complete, distance related issues as well as range failures caused due to extra work overload or also because of some software or hardware faults. Proposed approach gives an efficient fault tolerance algorithm in the system which performs a regular or the periodic checks energy level or the overall status of the different cluster heads. Sensors collected by a new cluster head by recovering from faulty cluster and shifted them to other clusters on the basis of backup information or overall status of alive sensor nodes.

Md Azharuddin, Pratyay Kuila, Prasanta K. Jana et.al [5] presents the Energy related issues of cluster heads for a large WSN models. Sensor nodes are dies quickly in many applications. Author presented a algorithm (distributed) DFCR for wireless sensor networks which are useful in proper cluster formation as well as for fault tolerant process. The cluster formation is based on the distance form nodes to their respective cluster head and the remaining energy residual energy of the CHs and distance between nodes to CHs and also the distance CHs to the base station. For proper clustering Author presented various experimental results using two different cases of the WSN. the proposed algorithm out performs the existing algorithms, in terms of number of dead Cluster Heads, energy consumption, number of message packets received by the base station from the different cluster heads. This algorithm is more energy efficient in terms of proper cluster formation and fault tolerant issues than the traditional algorithms in the sense of number of inactive sensor nodes or die cluster heads.

Pratyay Kuila, Prasanta.K.Jana et.al [6] presented a clustering scheme for wireless sensor networks, in which some high energy gateways are treated as cluster heads (CHs). The algorithm takes care of the load balancing as well as energy efficiency. Experimental results show that the proposed algorithm is more efficient with respect to load balancing and energy consumption than the similar works reported by Gaurav Gupta et al.[ ]. they also make an effort to devise a scheme for the cluster head selection.

Arati Manjeshwar and Dharma P et.al [8] introduced new protocol Hybrid protocol APTEEN which combines the best features of both proactive and reactive networks and to provide periodic data collection as well as near real-time warnings about critical events. Author also implementation of a query which is versatile enough to respond to a variety of queries. Even though, proposed algorithm system model is suitable for a network with evenly distributed nodes, it can be extended further to sensor networks with uneven node distributions.

SHANG Fengjun et.al [11] uses the LEACH algorithm as per each sensor node is gathering and transmit the information to the base station, the major motive of this paper is toward

reduce the power consumption of wireless micro sensor networks, first it extend the distance component of sensor so that it will reduce the energy consumption for energy efficiency of cluster head. Firstly modified the LEACH in such a manner that energy consumption will reduce. Follows are some assumptions for micro-sensor network:

- The base station is located among the sensor and immobile.
- All nodes in a network are homogenous and energy constrained.
- All nodes are able to reach base station.
- Nodes have no location information.
- Symmetric propagation channel.
- Cluster heads perform data compression.

First extend the LEACH"s CH selection algorithm by a factor with distance based deterministic component (distance vector) to reduce energy consumptions and author proves by simulating the result into NS2 simulation that this scheme will extend the network life around 40% before first node before dies.

Zuoming Yu, Xinfeng Li et.al [18] gives the solution of coverage problem in bounded areas, it will too difficult to employing optimal patterns for cover up bounded areas. Author approaches the problem starting from development of bounds on the basis of number of nodes which needs or uncovered nodes to cover a bounded area, after this design a different deployment patterns for different kinds of area patterns like convex and concave shapes such as rectangles and L shapes also hexagonal as well as circular shapes. Basically the main motive of this paper is to find how to optimally cover bounded areas with discs. Author proposed several deployment techniques or patterns for different kinds of deployment patterns for different kinds of deployment area.

By B.Baranidharan et.al [21] presents an study of the different routing techniques used in wireless sensor network and also gives the brief introduction and working strategies of energy efficient routing protocols in WSN. As we know, wireless sensor network is consists

of different components like sensor nodes, cluster head with a set of processor and memory unit and also system hardware which all combine for reliable routing of packets from sensor nodes to cluster head then cluster head to base station. As per the wireless sensor network the routing of packets form one system model to other is much more complex than other aany other communication based wired and wireless networks because the routing protocols not easily applied to any other network because of energy or battery related issues. Author also compared routing protocols based on metrics like stability, mobility and overlapping they also describes the energy efficiency in routing by taking the example of different energy efficiency based algorithms like LEACH, HEED and DECA,. Energy efficient routing:

- Clustering based
  - LEACH(low energy adaptive clustering hierarchy)
  - HEED (avoid arbitrary choice of CH)
  - DECA(distributed efficient clustering algorithm)
- Tree based approach
- PEGASIS(power efficient gathering in information system)

Author describes protocols like LEACH, HEED, DECA, SPIN, and PEGASIS, proved by comparing the system performance by taking results and prove that which one is more energy efficient and also compares them with its previous models and the main demerits in these protocols.

Chunyao FU et.al [33] proposes a new algorithm LEACH-TLCH(LEACH protocol with two levels cluster head) according to we know Electing group head arbitrarily in LEACH convention causes that the current vitality of some bunch heads are less or their separations to base station are far, in light of the substantial vitality trouble, these group heads will soon bite the dust. For this issue, this article proposed another enhanced calculation of LEACH convention which is go for adjusting vitality utilization of the entire system and developing the system lifetime by adjusting the vitality utilization of these group heads. The new enhanced calculation is imitated by MATLAB stage, the reenactment results demonstrate that the vitality proficiency and the lifetime of system are both superior to that of LEACH Protocol. However the strategy for group head choice and bunch shaping are same as LEACH convention. In the event that bunch head current vitality is not as much as normal

vitality or separation between the CH and base station is longer than the normal separation then the regular hub with the greatest vitality in this group chose as auxiliary group head. In a group which has auxiliary bunch head is in charge of getting and combining information gathered from the nodes and optional them to its group head. In bunch without optional head is in charge of gathering information from the part hub and sending them to base station after information was combined, as just with auxiliary head Clusters the life of group won't amplified.

Kamanashis Biswas, Vallipuram Muthukkumarasamy et.al [13] Introduced the self organizing single hop clustering scheme, which is basically based upon portioning the sensor networks into a small several disjoint cliques because clustering the sensor nodes into a small group is an effective method to approach scalability, fault tolerance, load balancing routing and satisfies other QOS standards. Author develops a maximal clique based cluster; firstly it obtains a list of all neighboring connectivity as well as cluster head to nodes connection, and then the node which exhibit higher degree of energy level then the connection initiates between the node to their respective cluster head or the clique formation process between the nodes which used to makes the cluster. Among all the members of clusters, the node with maximum energy is selected as CH; the proposed algorithm has an enormous advantages because it requires only the status of neighbor nodes to make the cluster or proper cluster formation. Author also proves by comparing the different parameters that this approach is better than the previous approaches like LEACH and LCA (linked cluster algorithm). Future work is also done in this approach by making it single to parallel approach which makes it faster by enhance the protocol by providing efficient routing and also adding some security parameters for protecting the network from various security attacks(malicious attacks).

Suraiya Tarannum et.al [14] describes the various energy efficiency problems and power related issues and describes the requirement of need for energy saving and optimizing protocols useful for long run operation of network without switching off the whole system because of cluster head failure or node failure. Basically WSN performs the three basic functions like sensing, computations and communication. WSN main challenges are energy, bandwidth and memory also processing ability among them because it will most difficult for

us to update or recharging the batteries of sensor nodes in which are deployed in remote areas (forest etc). As the sensor nodes are normally tiny and power-driven by non expendable batteries, power control become most important and almost demanding difficulty in scheming the WSN with maximum lifetime and also satisfying the QOS standards (latency throughput and reliability).

Author gives the following reasons WSN facing difficulties in energy conservation:

- As the sensor node are deploy randomly i.e. the not fit in regular topology, therefore the setup and maintenance need to be autonomous and deployment in such a way that it will easily communicate with the base station.
- Sensor network doesn't have proper infrastructure therefore all process like routing of packets and maintenance must be distributed.
- Hardware design of sensor nodes should also be designed as more energy efficient. The software, microcontroller and operating system should be designed so that it consumes minimum energy.
- Sensor nodes or cluster heads must be able to communicate or stationary with each other in completely distributed manner so that they easily communicate with each other or TDMA schedules are properly accomplished.
- A sensor network should also be able to change its connection status in case of sudden failure of nodes or back up set should be provided.
- WSN should gives guarantee of bandwidth, delay or other QOS standards define as per the requirement of application process.

Sudhir Agrawal et.al [28] presented survey study of the routing protocols, the attacks on routing and the proposed an efficient algorithm to remove these kinds of attacks in various other previous research works observed that much better research is being carried out in this field, but the previous work somehow not much efficient in terms of effective and efficient routing security or other security issues present in WSN. Author describes all limitations present and also gives solutions for that. The solutions might be of high computational or communication overhead or complex algorithms mostly in case of cryptography and key management based solutions which is deterministic in case of MANET(mobile ad-hoc networks), or they have the capability to communicate with only one single gateway node

and not much affected in case of multiple colluding attackers or intruders. More solutions may require for the hardware using in a system models such as a GPS (global positioning system) or a modification to the traditional protocols.

K.Ramesh et.al [18] Presents different clustering schemes which are classified as a special emphasis on their cluster head selection approaches and compared their results with respect to their need of (1) proper clustering during each round of communication for selecting the sensor nodes or cluster head on random basis i.e. every time the algorithm runs the nodes and cluster head deploy randomly, (2) proper cluster formation basic requirement that after each role of cluster head after each rotation done within a cluster, (3) cluster heads distribution over the network (gateway node distribution), (4) balanced clusters or each cluster require one group leader and nodes divided in every cluster on the basis of area, (5) algorithm based upon parameters used in system model and (6) focuses on the effect of cluster head selection strategy on the performance of these schemes (random and static). The survey contains all the process that needed at very beginning about the proper cluster formation and cluster head selection randomly or static. Need of these kind of parameters for comparison which is explained by reasoning the abrupt effects of cluster head selection process and CH role rotation on the basis of energy efficiency. Data packet forwarding process, on or after cluster head to base station, distance among the cluster head which is forwards the data packet and received cluster head shall be maintained approximately same during communication and during communication rounds, to completion or equal amount of energy consumption due to their data forwarding to main cluster head to nodes or cluster head to base station. Finally research methods explained by the survey report that presented by author, but still it is needed to find more scalable in terms of power efficient and proper clustering system, for information congregation and sensing into WSN.

Muhammad Imran et.al [19] changes the architecture of cluster based WSN by proposing a new approach named as “coordinator node algorithm”. This will not only help in long run operation of network but also increase the overall scalability of the network model. It also eliminates the need of communication to reach at the Base station. Author also proposes an efficient algorithm for cluster head selection on random as well as static basis based on K-Theorem methodology and four parameters i.e. remaining residual energy distance to the

cluster head node, reliability and degree of mobility. In K-theorem it selects cluster heads based on remaining energy of sensor nodes within a cluster for making system more reliable. The K-theorem performs much better against sensor nodes deployment in a cluster both whether the deployment is random or static also even or uneven, whether nodes are stationary or mobile in cluster. Proposed algorithm not only decreases the communication cost but will also increase the reliability or scalability of the WSN.

Ameer Ahmed Abbasi, Mohamed Younis et.al [20] presents survey on the state of the research and classified the different schemes, the survey on Wireless sensor networks basically focuses for civil and military applications which can employ WSNs for improving the traditional systems especially in hostile and remote areas. Examples include disaster management, border protection, combat field surveillance. In these applications a large number of sensors nodes are expected, requiring careful architecture and management of the overall network. Grouping nodes into clusters has been the most popular approach for improved scalability in Wireless Sensor Networks. Also highlighted the effect of the network model on the pursued approaches and summarized a number of schemes, stating their strength and limitations.

Das Prashanta Kumar et.al [22] presented the study of proactive protocols by growing the value of sensor nodes in network by considering the source node fixed and movable sink node and lastly, keeping the destination node fixed and move sink node. Author considering three main cases, based upon the behavior of the routing protocol that has been examined to choose efficient and long run operation routing protocol for efficient network setup.

Haiying Shen et.al [27] proposed in their work an ALERT (Anonymous Location-based Efficient Routing protocol). It partitions the sensing field into zones. The nodes from the zones are randomly selected as relay nodes. The relay nodes make a non traceable route. The data of initiator or receiver is hidden to provide protection. There are many strategies to counter the timer attacks and intersection. ALERT features a dynamic and unpredictable routing path, which consists of a number of dynamically determined intermediate relay nodes.

CHAPTER 3

Research methodology:

3.1. Objectives of study

The main objective of implementing the improved DFCA algorithm is that for decreasing the vitality utilization and expanding the adaptability of WSN the calculation is utilized however the cluster based WSN expend more vitality because of additional work burden, because of disappointment of group heads in this way for productive grouping calculation or as it were for effective cluster development which equipped for gathering information and perform information accumulation in fitting way. We oblige a calculation which is fit for long run operation furthermore productive regarding recoup the framework from the bunch head disappointment. As examine above parts, it will concentrates on the correct group arrangement and adaptation to non-critical failure system for this the enhanced DFCA (an appropriated deficiency tolerant bunching calculation) calculation is utilized which utilizes an expense capacity of CH. For putting forth bunch in defense of sudden disappointment of CH and it gives move down set and move down hub which will dynamic amid high rate of group disappointment. This move down set essentially gathers the uncovered sensor nodes and joins them with the principle group head. Furthermore, at any case if the group head falls flat it gathers the vitality thought from the other part sensor nodes and make the hub bunch head which have staying most astounding leftover vitality Add a new clustering algorithm in the MATLAB environment.

- Deployment of sensor nodes as per requisite of main system model.
- Proper cluster formation.
- Sudden recovery of cluster in case cluster head failure.
- To make the system more energy efficient.

3.2 Approach to study

The base proposed algorithm DFCA mechanism can be divided into two parts

- Cluster formation

- Fault tolerance

3.2.1 Cluster Formation:

STEP 1: All the sensor nodes deployed randomly then the cluster heads selects randomly from every cluster then cluster head broadcast a hello message to all sensor nodes which consist of sensor nodes id, remaining residual energy and distance to the base station.

- 60 nodes represents by $S = \{S1, S2, ..., Sn\}$
- 5 CHs denoted by $CH = \{CH1, CH2, ..., CHm\}$
- $Dist\ (Si, S\,j\ )$ denotes the distance between two nodes *Si* and *Sj*.
- $Eresidual\ (Si)$ denotes the remaining energy of *Si*.
- *Communication distance range CH* (*Si*) is the set of those entire cluster heads, which are within the communication distance range (*RS*) of sensor node *Si*.

$$Com\ Range\ CH(Si\ ) = \{Gj\ Dist(Si\ ,Gj\ ) \leq RS \wedge Gj \in G\} \qquad 3.1$$

Step 2: After broadcasting the HELLO message system waits for the reply from the different sensor nodes those nodes respond to CH are considered the covered node otherwise uncovered node. Depending upon the distance measure and communication range coverage of sensor nodes and cluster heads the formulae for covered, uncovered and backup set are as follows:

- **Covered Set, Uncovered Set:**

  Sensor nodes which comes in coverage area of cluster head are considered as covered sensor nodes on the other side those are not comes under the sensor node are considered as uncovered sensor node .there is one backup node is provided with every cluster which used to communicate the uncovered sensor nodes with the cluster head.

  For Covered set: $Si \in COset \Leftrightarrow [\{\exists\ Gj\ Gj \in ComRangeCH\ (Si\ ) \wedge\ Gj \in G\}]$ 3.2

  For Uncovered set: $Si \in UnCOset \Leftrightarrow [Si \notin COset\ ]$ 3.3

- **Back up set:**

  Those sensor nodes are under uncovered set broadcast a HELP message for backup then first it will connected with backup node and then backup node further connect them with the cluster head. formulae for back up is as follows:

$$BackupSet(Si\ ) = BackupSet(Si\ ) \cup S\,j \qquad 3.4$$

Step 3: Sensor node calculates cost of all these CHs according to equation 1.5 and joins the CH with the highest cost value.

$$CH\_Cost(Gî,Sj)=\frac{Eresidual}{dist(Sj,Gî)*dist(Gî,BS)} \quad 3.5$$

- **Residual Energy of CH**:

  Sensor node should join that CH which has higher residual energy than any other CH

  $$CH\_Cost\ (Gi, S\ j)= \square\ \square E\ residual\ (CHmi\ ). \quad 3.6$$

- **Distance from Sensor node to CH**:

  As non-CH sensor nodes consume maximum energy to communicate with its CH, sensor node should join the nearest CH. The shorter the distance higher is the chance to join. Therefore,

  $$CH\_cost= (Gî,Sj)\propto 1/dist(^{Sî}/_{Gj}) \quad 3.7$$

- **Distance from CH to Base Station:**

  Gateways are capable of long-haul communication compared to sensor nodes and can direct communicate with the BS. Thus the gateways which are far away from the BS, consumes more energy for long-haul communication to the BS. Therefore, cluster member of these CHs should be less than that of the CHs which are nearer to the BS.

  $$CH\_cost= (Gî,Sj)\propto 1/dist(^{Gî}/_{BS}) \quad 3.8$$

Step 4: At the end of cluster formation, CHs receive the sensed data from their member sensor nodes and perform data aggregation to reduce the redundant and uncorrelated data within their cluster. The CHs then route their aggregated data directly to the BS. This completes a single round.

3.2.2 Fault Tolerance:

The other period of DFCA is adaptation to non-critical failure at any specific round if the cluster head falls flat because of additional work burden or whatever other force effectiveness related issue then it influences entire the framework or the specific cluster to defeat this issue DFCA recognizes the flaw at whatever point it doesn't get any affirmation or answer message it will likewise distinguished by part sensor nodes in light of the fact that around then because of disappointment of bunch head other part nodes additionally stops

meets expectations. At the point when issue is recognized, the neighbor part sensor nodes of the disappointment uncovered node show a HELP message with in its own particular separation correspondence range. Once again the sensor nodes become the elements of *COset* , after getting replies from the CHs otherwise they become the elements of *UnCOset* . The sensor nodes j , j *set* , $S \forall S \in CO$ join a CH considering the same cost value as in equation (3.8). The sensor nodes Si , $\forall Si \in UnCOset$, reset *Backup Set* (Si) by the sensor nodes, those have replied the HELP message. If the backup set is not empty (*Backup Set*(Si) $\neq 0$), Si uses a sensor node j , j (i), S $S \in$ *Backup Set* S works as a relay node with highest residual energy and send the data to the CH.

Step 1:

Uncovered sensor nodes broadcast a HELP message within its communication range.

$$Com\ Range\ CH(Si) = \{\}; \quad 3.9$$

$$Backup\ Set\ (Si) = \{\}; \quad 3.10$$

Step 2:

If no reply comes then the backup node is calculated the remaining energy of member sensor nodes of that particular cluster by equation 3.8.

Step 3:

Then the sensor node with maximum residual energy remaining becomes the cluster head of that faulty cluster.

3.2.3 Expected outcomes of DFCA algorithm

The simulation set up used is intel core i3 processor with the clock speed of 2.27GHZ and memory of 3GB. The development environment is MATLAB 2013a

3.2.3.1 Cluster Formation

Step 1:First plot the base station at area of 50/50 meters and deploy randomly 60 sensor nodes as shown in figure 3.1.

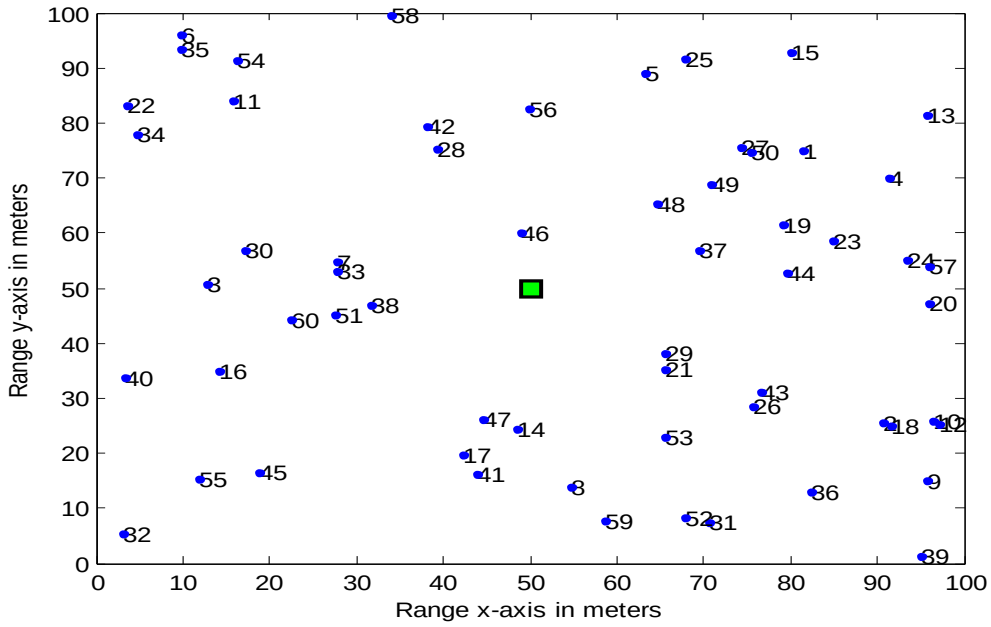

Figure 3.1 Randomly deployed sensor nodes and base station

Step 2: All the sensor nodes and cluster heads are deployed randomly into the sensing region and they are stationary after deployment. As shown in figure 3.2

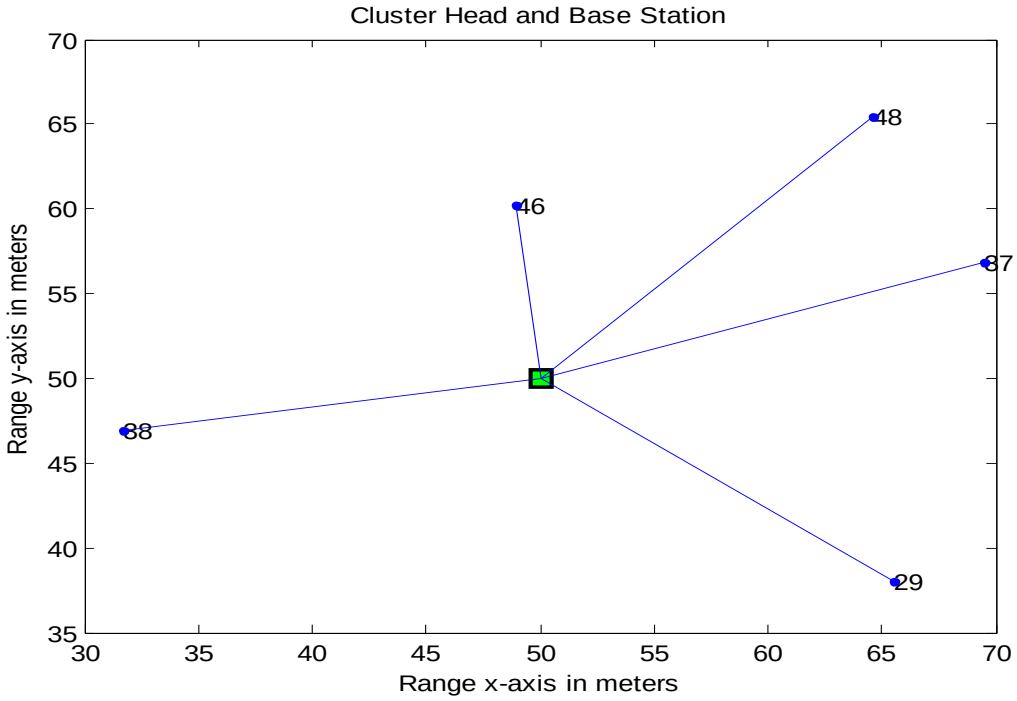

Figure3.2 Randomly selected Cluster head and base station

The cluster head selection is different every time we run the algorithm basically the cluster head selection is based upon the energy consideration of sensor node from different clusters.

Step 3: All The Sensor Nodes Are Connected To Cluster Head First At A First Round Following Figure 3.3, 3.4, 3.5, 3.6, 3.7 Shows The Five Different Clusters In Which The Sensor Nodes Are Directly Connected With The Cluster Head.

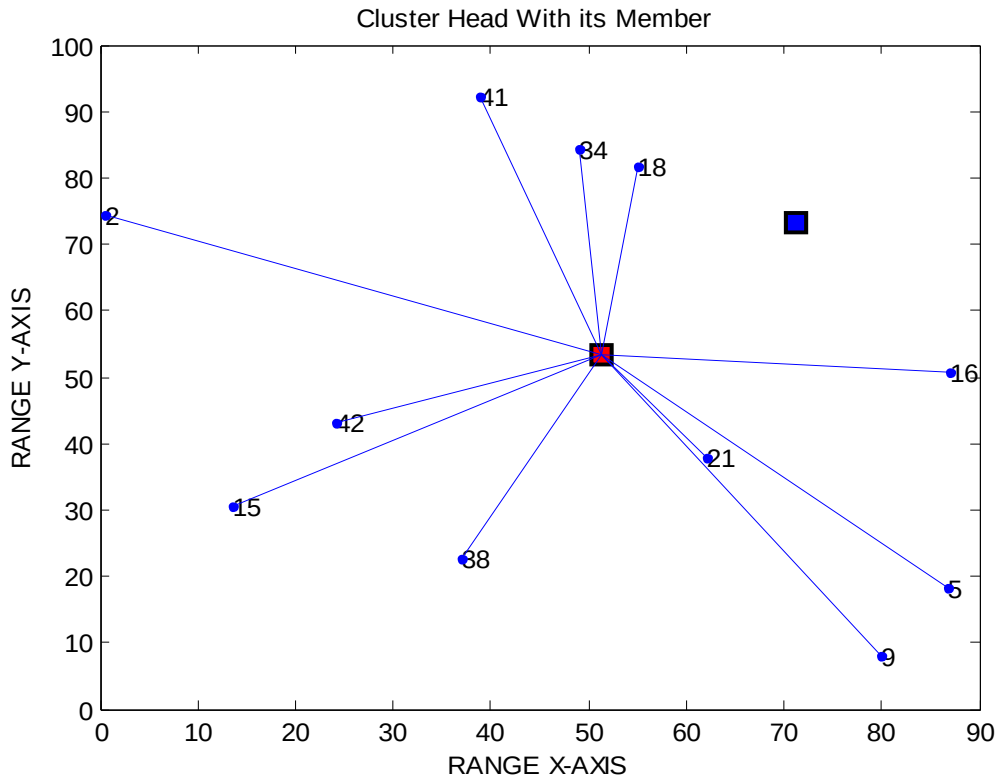

Figure 3.3 Cluster head 1 with its member sensor nodes

Backup node indicates with a blue color small squared shape in a cluster is basically activated only when it received HELP message from uncovered nodes or also at the time of cluster head failure at this point there is no need of backup node because all the sensor nodes are alive at this instance if time so there is not much requirement of backup node at this time as shown in results, the algorithm works on the phenomenon that the sensor nodes are become stationary to each other after they randomly deployed in their respective cluster.

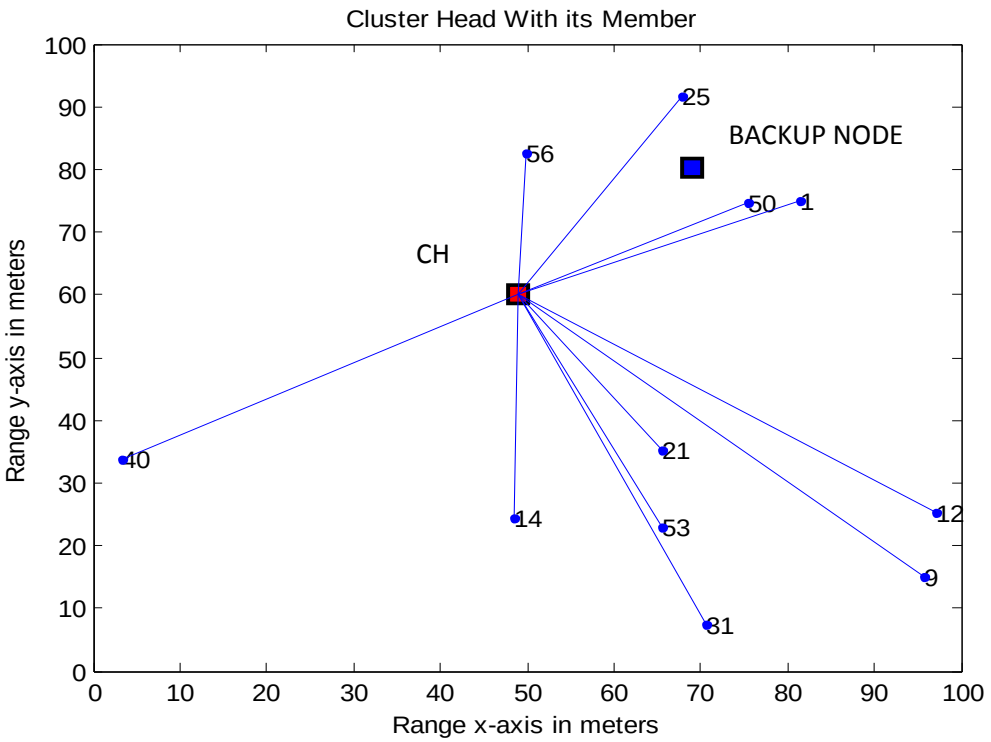

Figure 3.4 Cluster head 2 with its member sensor nodes

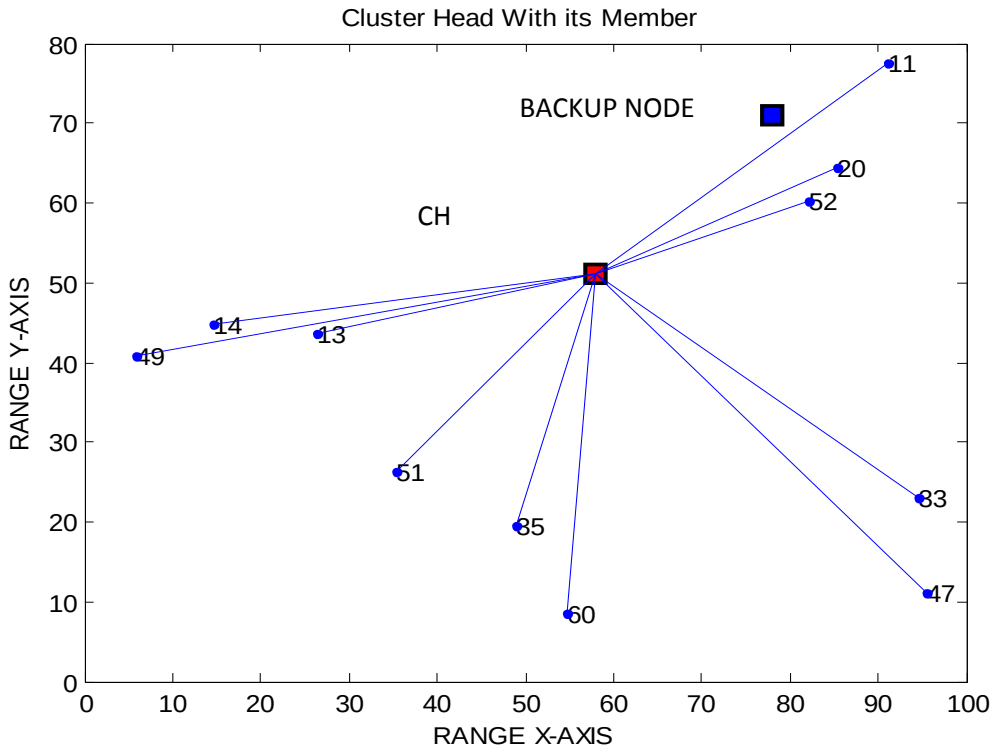

Figure 3.5 Cluster head 3 with its member sensor nodes

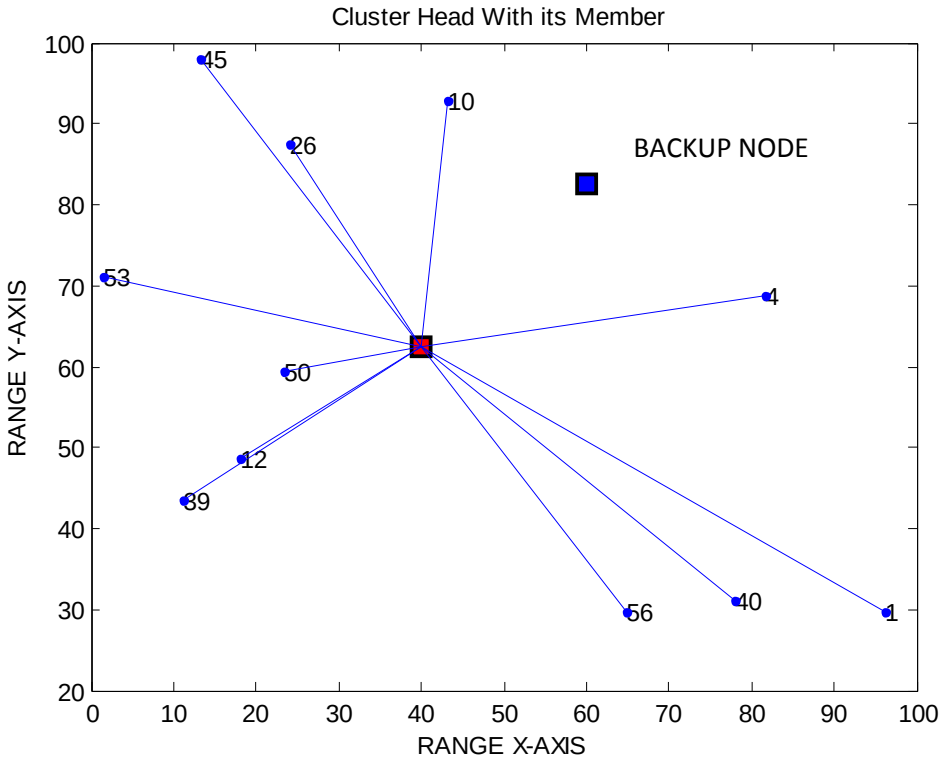

Figure 3.6 Cluster head 4 with its member sensor nodes

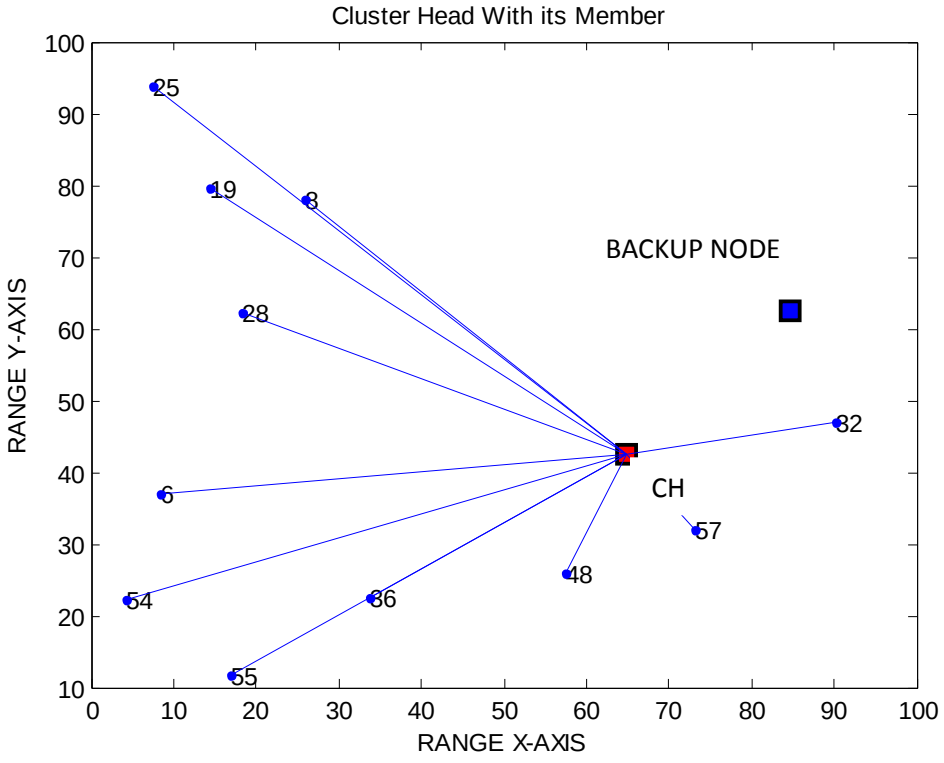

Figure 3.7 Cluster head 5 with its member sensor nodes

Step 4: Uncovered Sensor Nodes Broadcast A Help Message To Back Up Set Then The Backup Node Connected With The Uncovered Sensor Nodes FIGURE 3.8, 3.9, 3.10, 3.11, 3.12

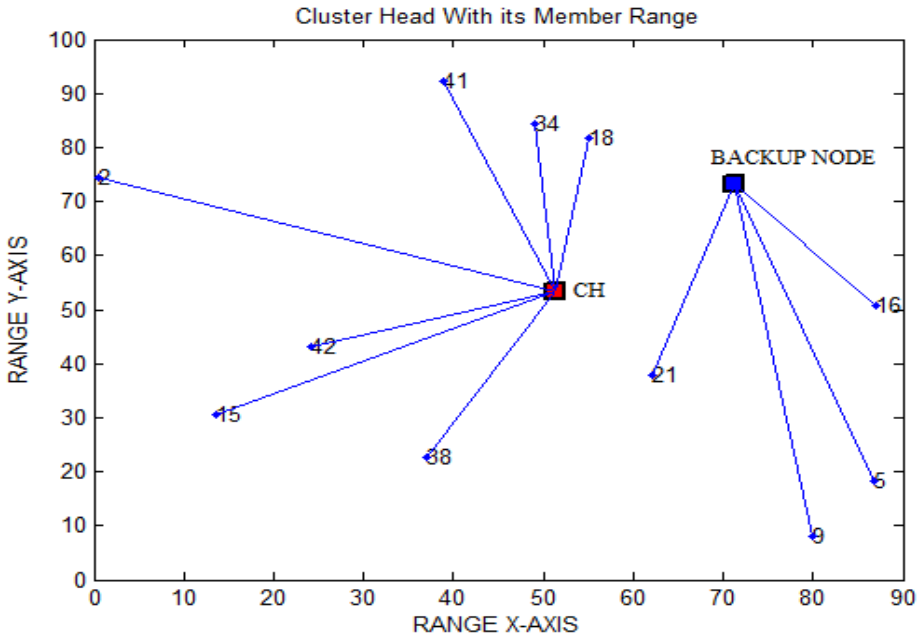

Figure 3.8: Cluster 1 uncovered nodes connected with backup node

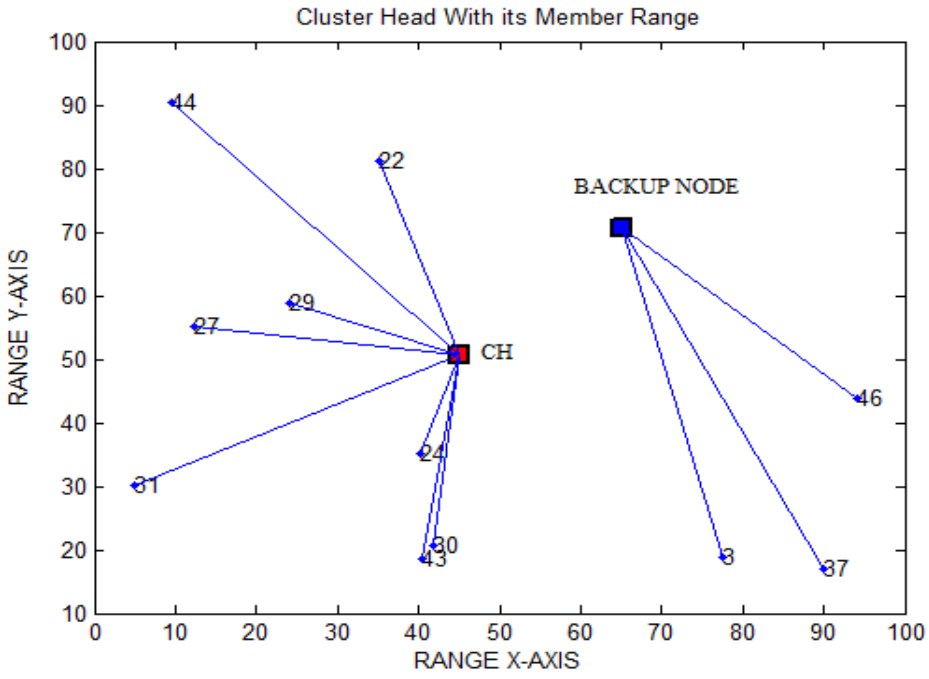

Figure 3.9: Cluster 2 uncovered nodes connected with backup node

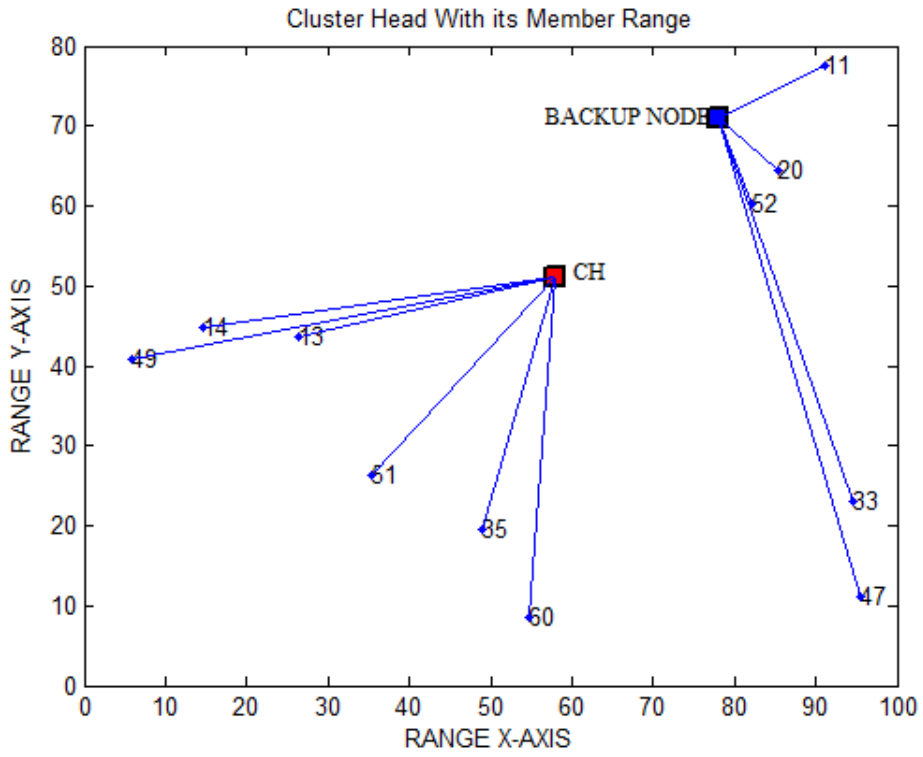

Figure 3.10: Cluster 3 uncovered nodes connected with backup node

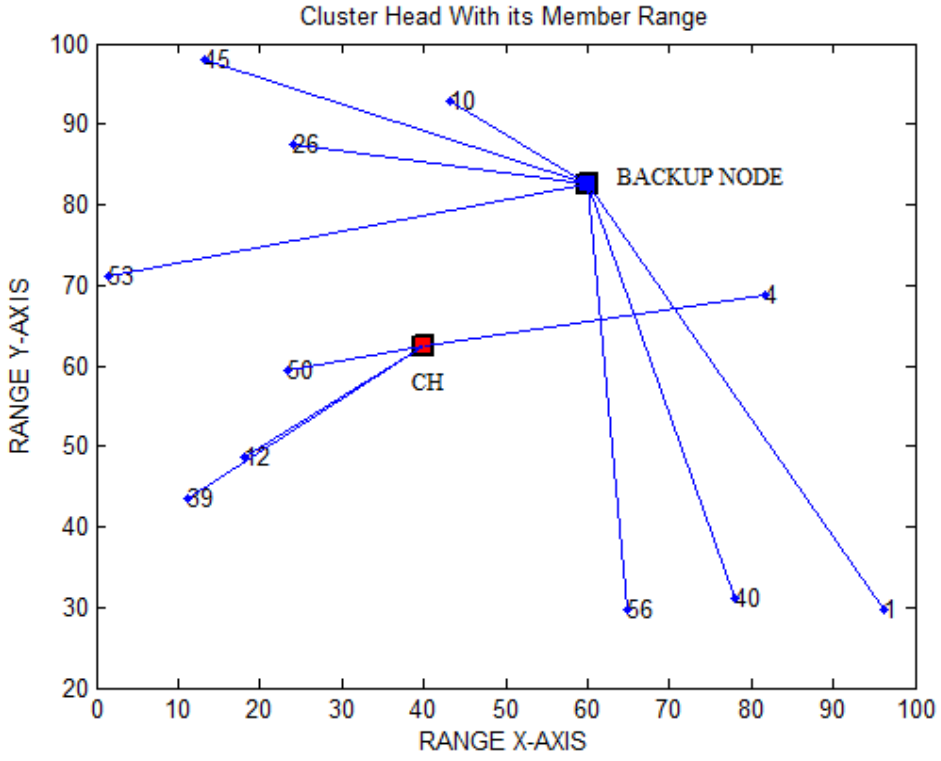

Figure 3.11 Cluster 4 uncovered nodes connected with backup node

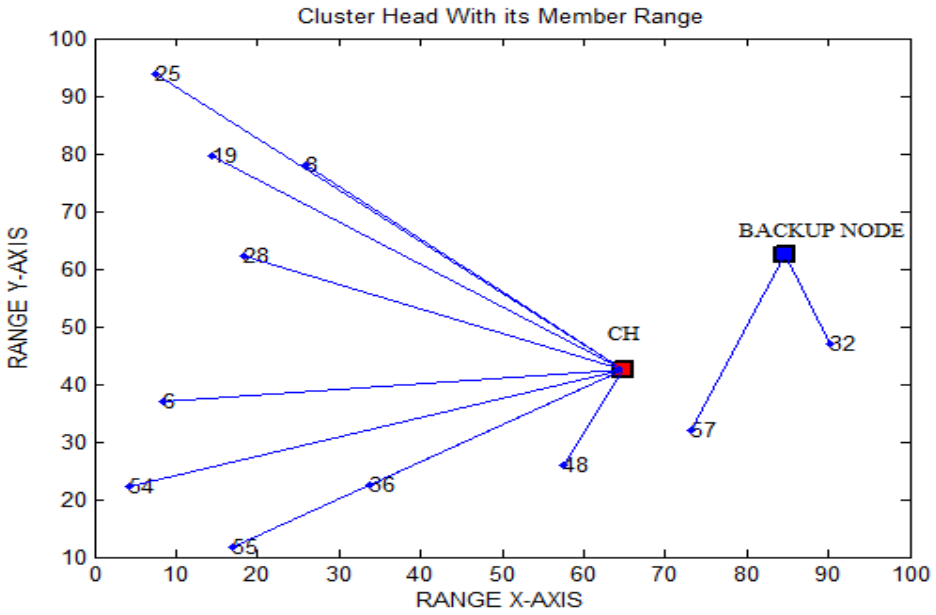

Figure 3.12.Cluster 5 uncovered nodes connected with backup node

STEP 5:

Backup Set Forward Connects The Uncovered Sensor Nodes With The Cluster Heads. FIGURE 3.13, 3.14, 3.15, 3.16, 3.17 shows all the uncovered sensor nodes which previously connected with the backup set is now forwards to cluster head.

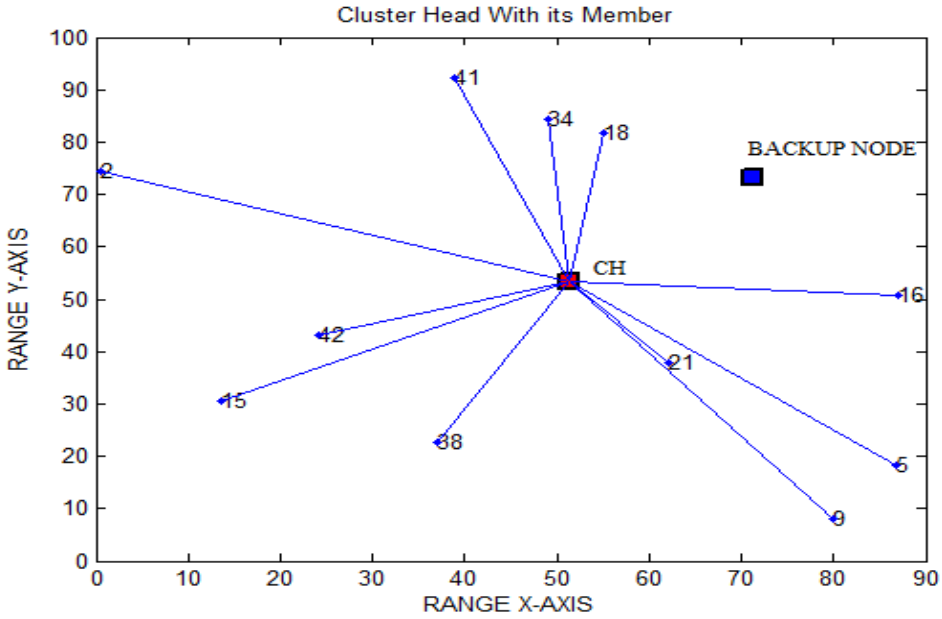

Figure 3.13 Cluster 1backup node forwards the uncovered set to CH

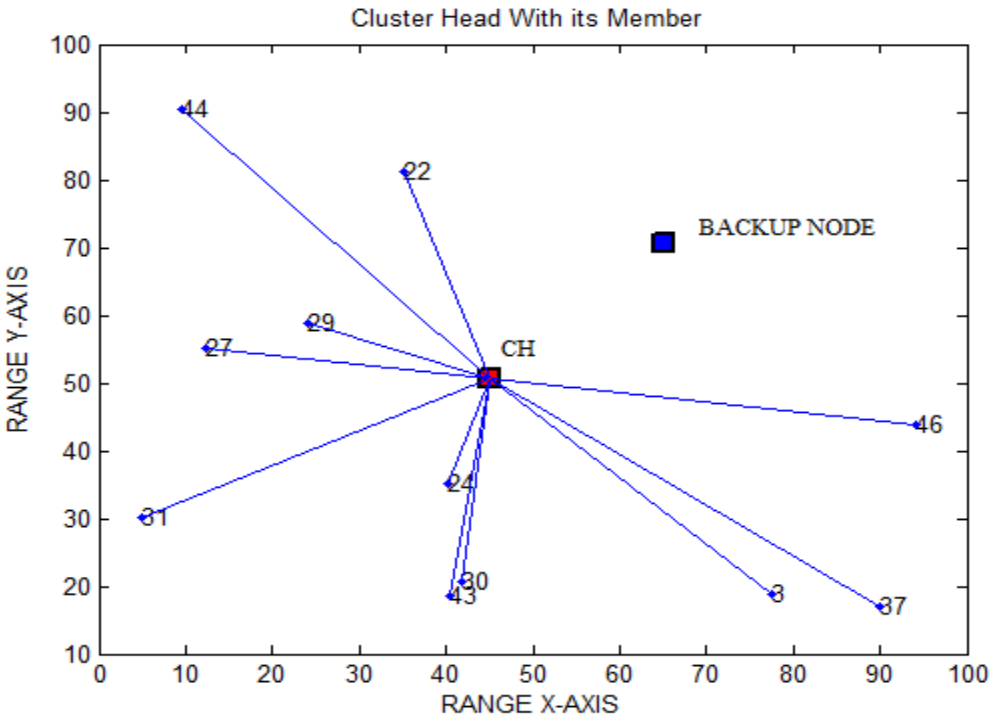

Figure 3.14 Cluster 2 backup node forwards the uncovered set to CH

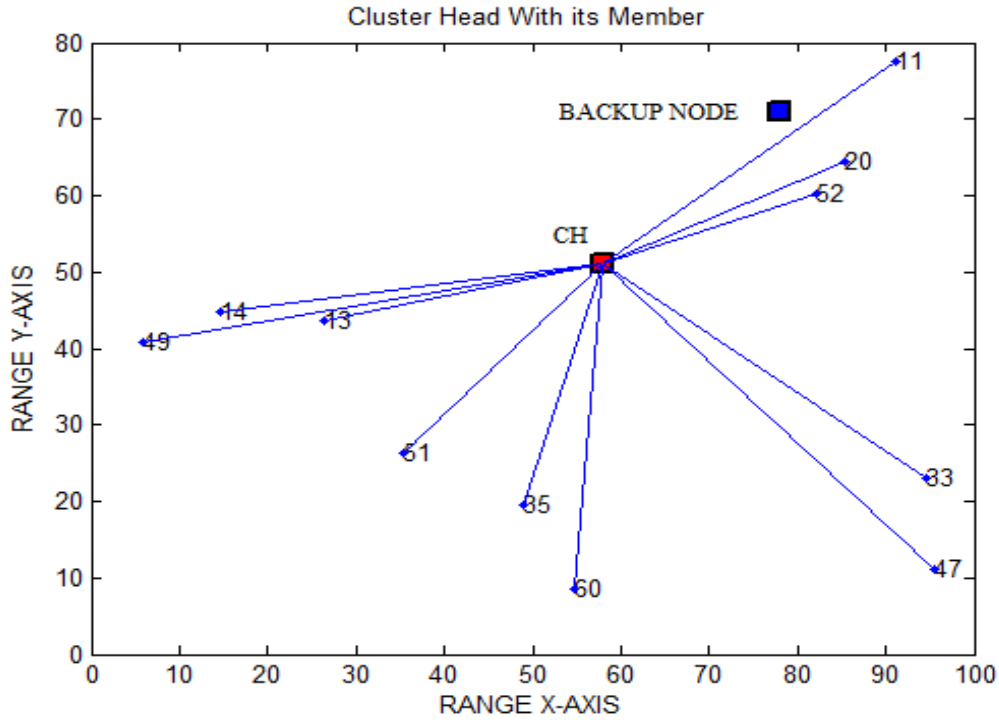

Figure 3.15 Cluster 3 backup node forwards the uncovered set To CH

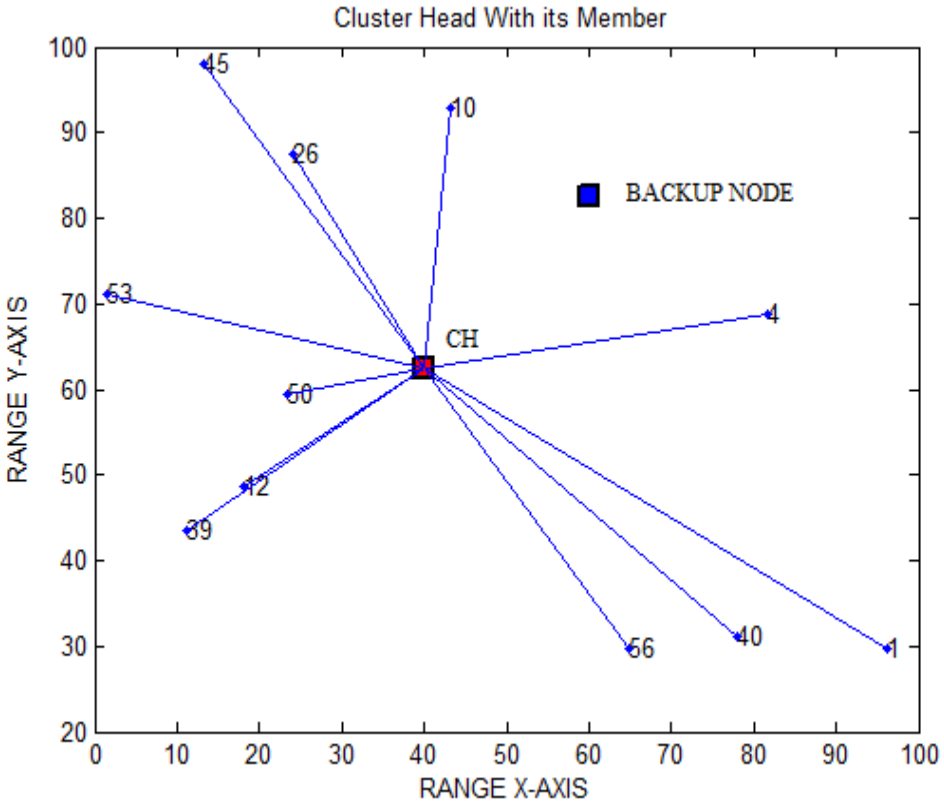

Figure 3.16 Cluster 4 backup node forwards the uncovered set to CH

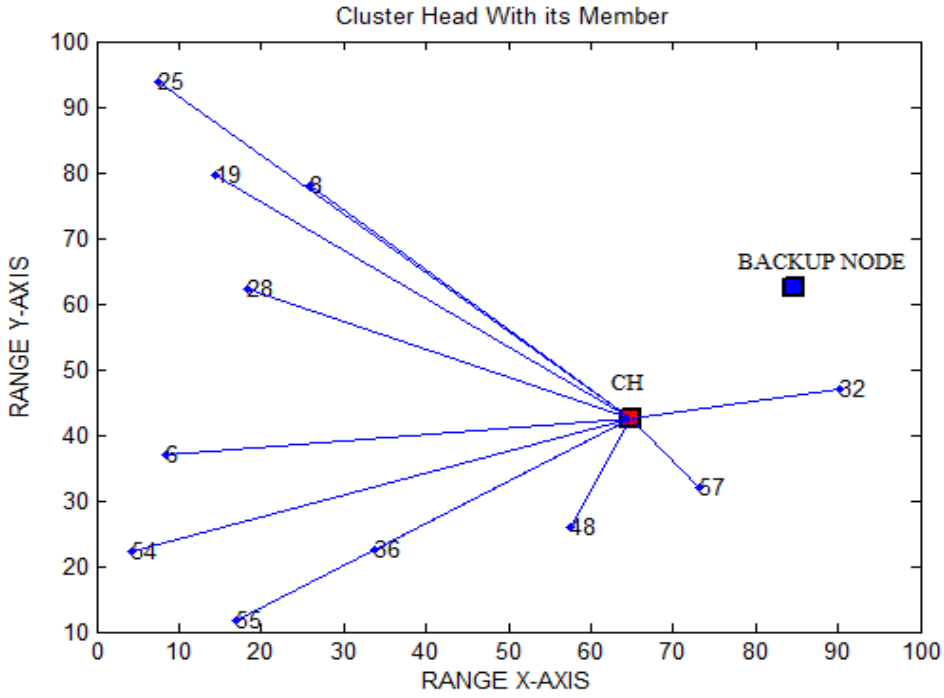

Figure 3.17 Cluster 5 backup node forwards the uncovered set to CH

3.3 Scope of study

Research on WSNs has been ascending as a basic new space in remote innovation. Sensor framework holds the guarantee of empowering sweeping scale and constant data figuring in registering convoluted situations. The adequacy of remote sensor system depends upon the best possible bunch development and adaptation to internal failure of specific system. A group based remote sensor system has gigantic points of interest like it lessens high vitality utilization, keeps up correspondence data transfer capacity and enhances general framework execution of the entire system. However every framework accompanies a bad marks in it, in the event of grouping approach, a bunch head falls flat because of some additional work burden while accepting information sent by the part sensor nodes though in numerous sensor organizes the group heads are generally chosen from the ordinary sensor nodes without figuring there vitality this reason to group that it bites the dust rapidly because of additional work burden.

Earlier than in remote sensor arrange have be number of combination methodologies are utilized

- LEACH(low energy adaptive clustering hierarchy)[2]
- HEED(avoid random selection of CH's)[3]
- DECA(distributed efficient clustering algorithm)[11]

But they are not much efficient. Then algorithm DFCA show the outstanding results when it compares with the previous approach of proper cluster formation and fault tolerance. The results compare previous algorithm in future by implementing the algorithm based upon the next-hop selection algorithm will helps to recover the cluster head failure. When a cluster head from faulty cluster does not receive any replies from its neighbor member CH, it detects that cluster head as failed CH. It will also be confirmed by checking the replies of another neighbor CHs. [6] in cluster based system the failure of one or more CHs does not create much problem in communication phase for other clusters if there is at least one live CH serve as a relay node. But at some instance there may be a situation occurs when a CH may or may not have any CH with low energy. Then the Cluster Head increases its hop count by one by using back up set and broadcasts the same to its neighbors cluster head to update their hop count or energy level. It's a time when the CH searches for other CHs those having lesser hop count than its own energy level. But everything comes with a disadvantage in my

research work, improved some disadvantages of DFCA as per at the beginning there is no requirement of backup set so in my work I removed the backup set at a beginning phase or first rounds we implemented a algorithm in which uncovered node is nearest to CH will first collects all the other member uncovered nodes then it will be forward to their respective CH. And on the basis of sensor node die a threshold value will be given in algorithm when number of sensor node die rate is increases that threshold level then the backup set will activated which collects all uncovered nodes and forward them to their respective cluster head.

The main scope of study for improving DFCA(distributed fault tolerance clustering algorithm) is that the lots of work done under this algorithm to make it more effective or efficient by taking consideration or removing the backup set phenomenon from it because for every backup node extra power energy is required and as explained above further approaches by taking consideration of next hop selection is also makes it more efficient for use as clustering formation and also it takes part in efficient fault tolerance mechanism by calculating the remaining energy of member sensor node and it will easily shifts the power to other highest residual energy exhibit node.

3.3 Research Method

In this research, a new routing protocol has been implemented. In order to proceed research; literature survey must be done. Literature survey is to exploit the research and gather information about methods to approach. After doing literature survey next step is to formulate the hypothesis which can lead to better results and then formulate the problem based on the analysis

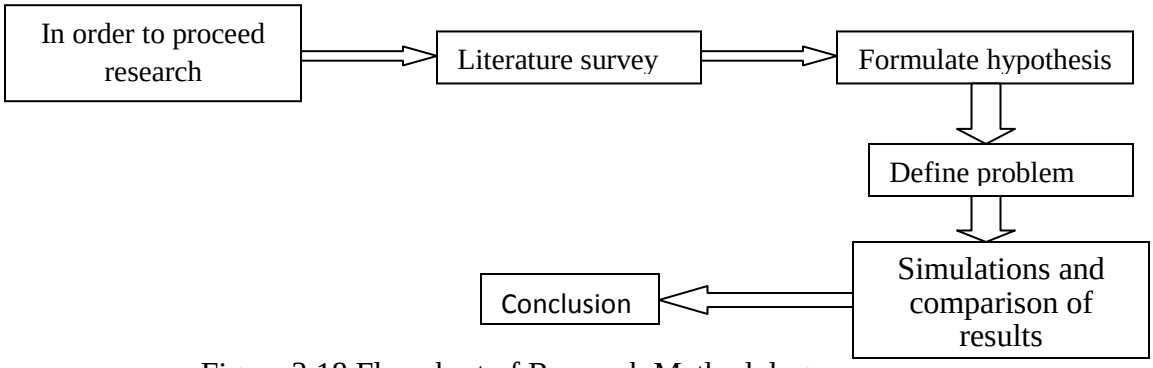

Figure 3.18 Flowchart of Research Methodology

3.4 STEP WISE EXECUTION OF METHODOLOGY

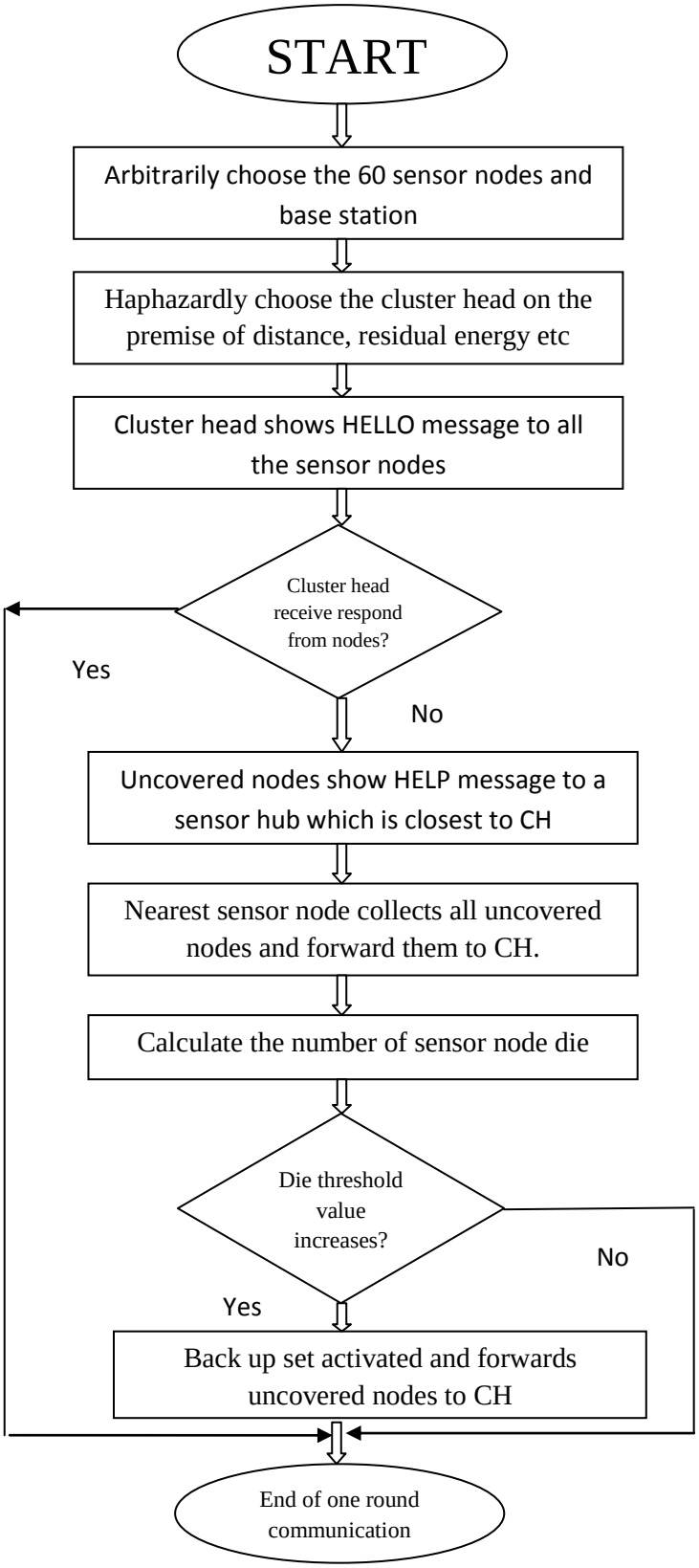

Figure 3.19 Flowchart of approach and applicability of methodology followed

The flowchart shows the steps towards approach and applicability of the methodology. Starting steps are similar to DFCA algorithm but in the step 3 new approach is added in which the unattended node which is nearest to cluster head will collect all the uncovered nodes and ahead them to their individual cluster head and the threshold value will provided on the basis of die rate of sensor nodes. The entire outcome is implementing in MATLAB 2013a first from the cluster formation it will finish at the fault tolerance. The planned algorithm improved DFCA implement as per the follows:

Step 1: First position the base station at 50/50 area in normal graph and 60 sensor nodes are deploy in area of n*n meters. All the sensor nodes go round into immobile to each other after deployment (random deployment) i.e. all nodes are communicate by means of each other and separated into dissimilar bunch which name by clusters after that in all clusters the cluster head is chosen. [6]

Step 2: HELLO message is transmitted by all the group heads to their particular part sensor nodes then sensors which are in scope of cluster head or those answer to cluster heads are considered in secured situated and those not answer are goes under the revealed set i.e covered or uncovered set.

Step 3: A new approach is added to improve the existing algorithm DFCA that the sensor node which is nearest to cluster head collects all the uncovered sensor nodes and ahead them to their individual cluster head this process continues till then the sensor node die rate will not exceeded to threshold given in between the system network model.

Step 4: In case the sensor nodes die rate will exceeded the threshold value then BACKUP set is activated and the old technique will works again i.e. backup set collect all unattended nodes and forward unattended nodes to their individual cluster head.

Step 5: On the off chance that any cluster head comes up short because of additional work burden or some other power related issue then reinforcement set figures the staying remaining vitality of part sensor nodes and the hub with most noteworthy leftover vitality turns into the group leader of that specific group.

CHAPTER 4

Results and simulation:

The simulation set up used is intel core i3 processor with the clock speed of 2.27GHZ and memory of 3GB. The development environment is MATLAB 2013a.

4.1 Cluster formation:

Step-1: Plot the 60 sensor nodes randomly in 100*100 meters and first plot the base station at the area 50*50 meters by taking consideration of x-axis and y-axis parameter of standard graph.

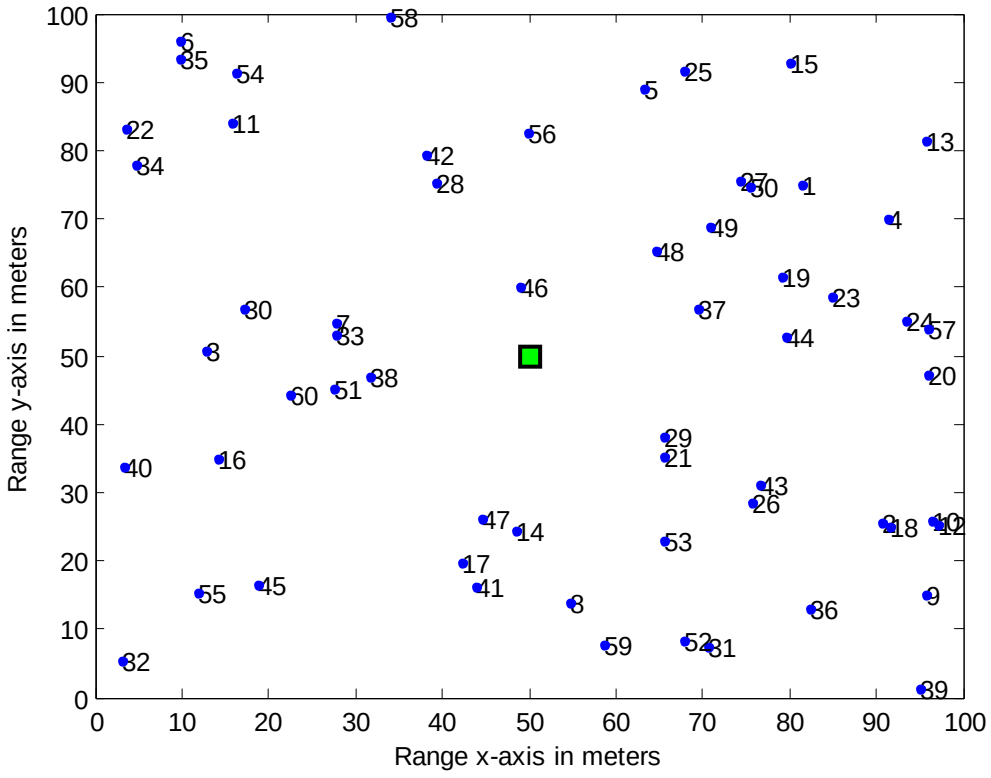

Figure 4.1 Plot base station and sixty sensor nodes in a region of 100*100 meters

Step-2 Every sensor nodes and cluster heads are deployed randomly into the sensing region and they are stationary after deployment. As shown in figure 4.2.

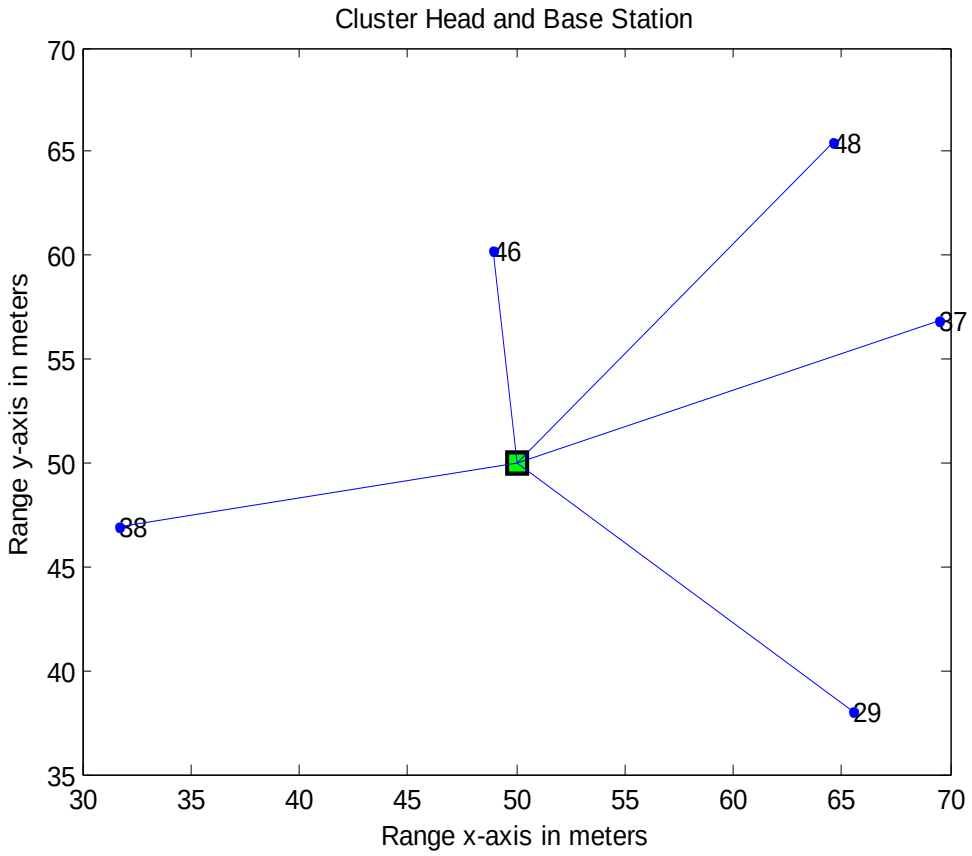

Figure 4.2 Base station and 5 cluster heads

The cluster head selection is different every time we run the algorithm basically the cluster head selection is based upon the energy consideration of sensor node from different clusters.

Step 3: All the sensor nodes are connected to cluster head first at a first round following figure 4.3, 4.4, 4.5, 4.6, 4.7 shows the five different clusters in which the sensor nodes are directly connected with the cluster head.

HELLO message is transmitted by all the group heads to their particular part sensor nodes then sensors which are in scope of cluster head or those answer to cluster heads are considered in secured situated and those not answer are goes under the revealed set i.e covered or uncovered set.

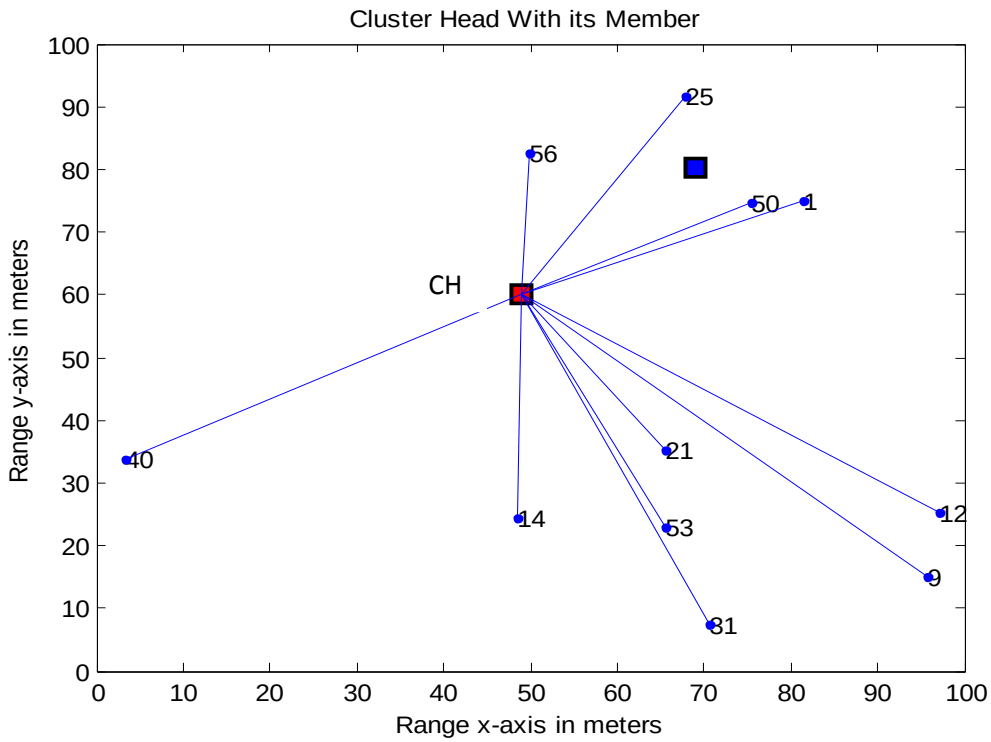

Figure 4.3 Cluster head 1 with its member sensor nodes

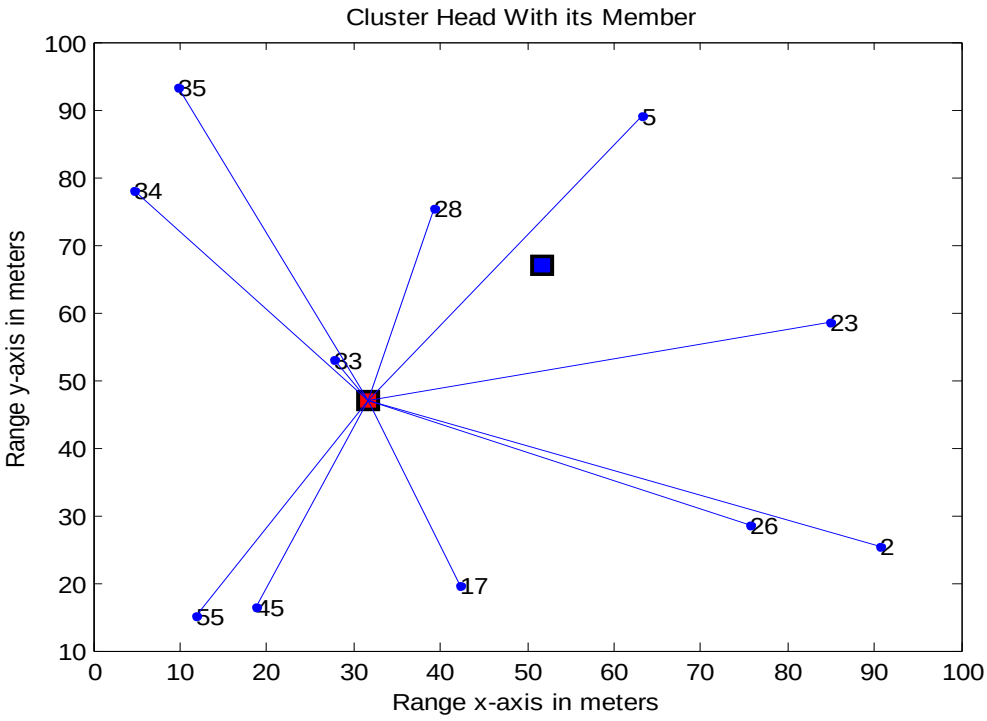

Figure 4.4 Cluster head 2 with its member sensor nodes

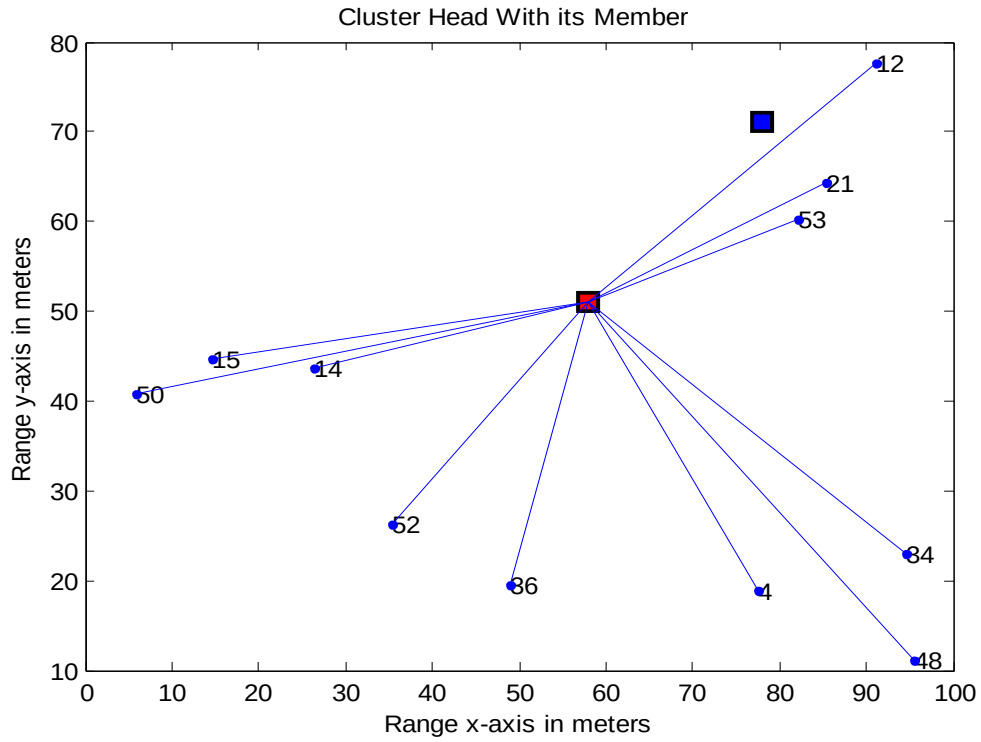

Figure 4.5 Cluster head 3 with its member sensor nodes

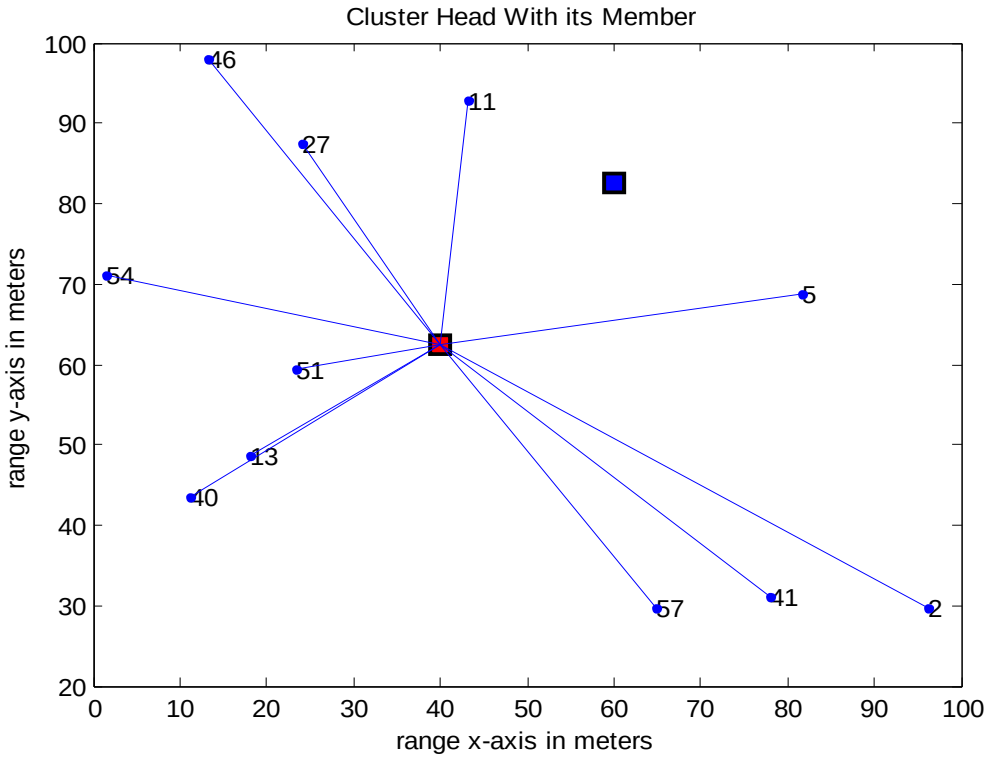

Figure 4.6 Cluster head 4 with its member sensor nodes

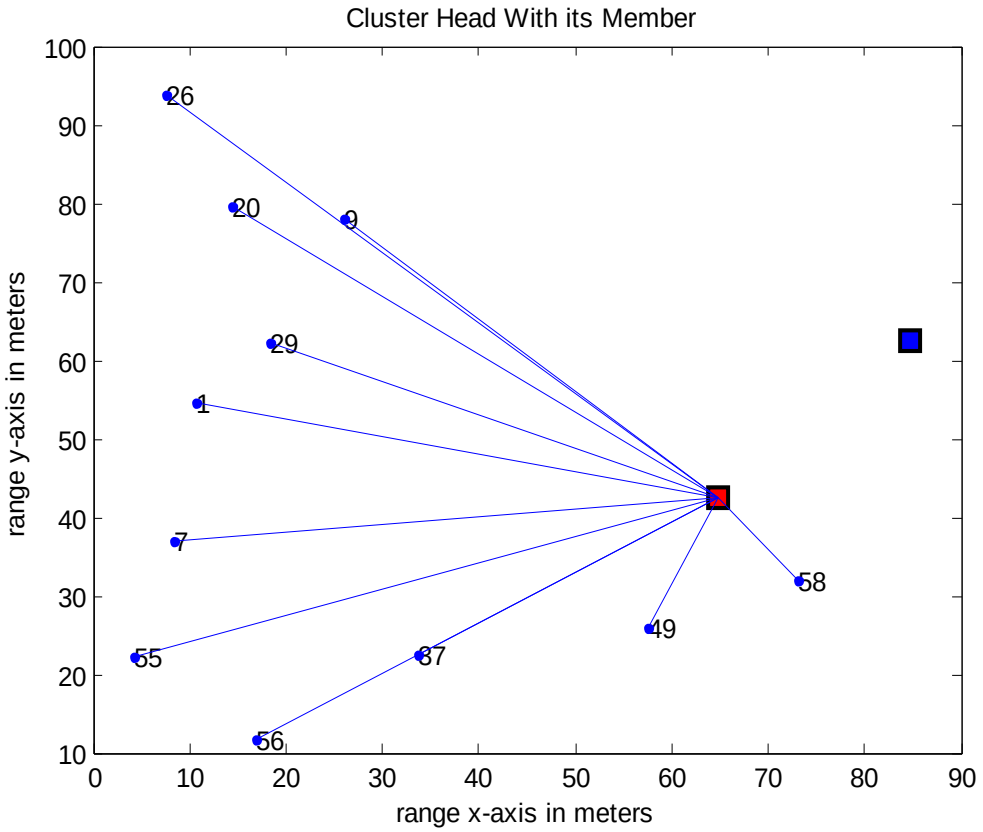

Figure 4.7 Cluster head 5 with its member sensor nodes

Step-4 A new approach is added to improve the existing algorithm DFCA that the sensor node which is nearest to cluster head collect all the unattended sensor nodes and forward them to their individual cluster head this process continues till then the sensor node die rate will not exceeded to threshold given in between the system network model. As shown in figure 4.7, 4.8, 4.9, 4.10, 4.11 when cluster head not receives reply from the member sensor nodes or when uncovered nodes which are not in range of at least one cluster head broadcast the message HELP and then all the uncovered sensor nodes become stationary to each other and which node is most nearest to cluster head forwards all the uncovered sensors node to cluster head.

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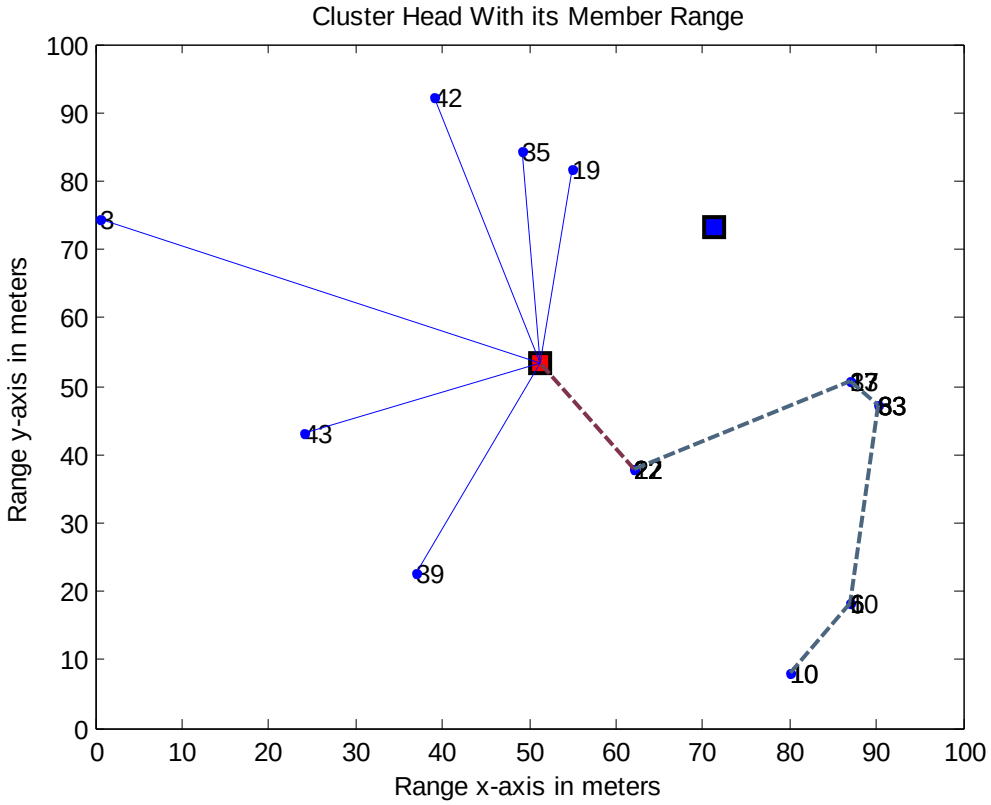

Figure 4.8 (Cluster-1) Nearest uncovered node forwards all the uncovered node to CH

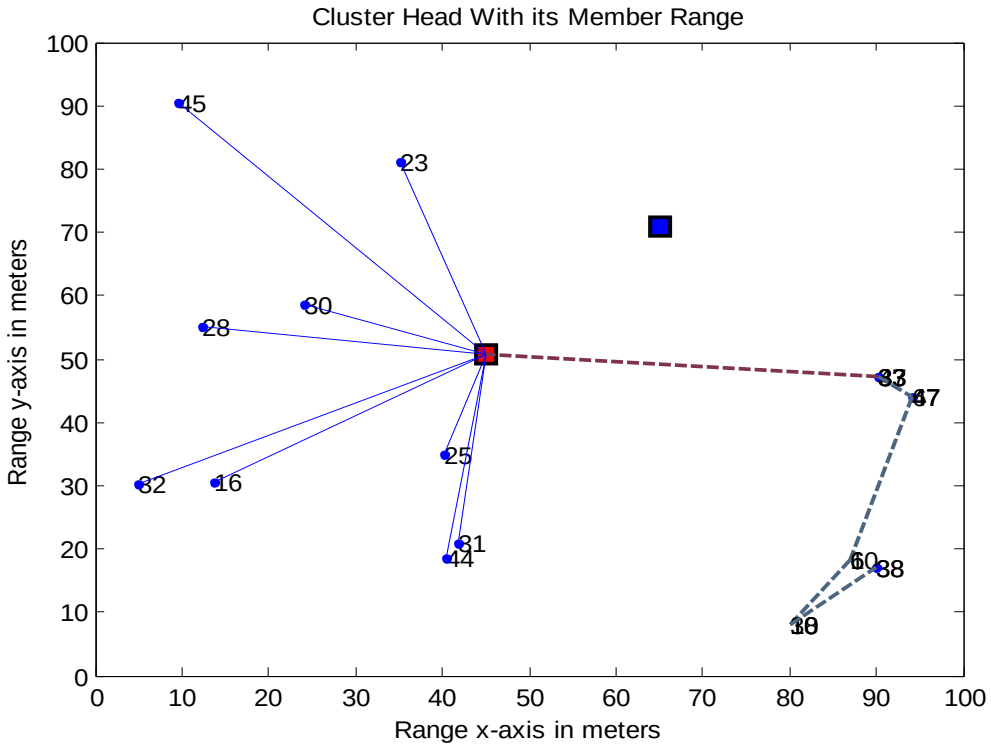

Figure 4.9 (Cluster-2) Nearest uncovered node forwards all the uncovered node to CH

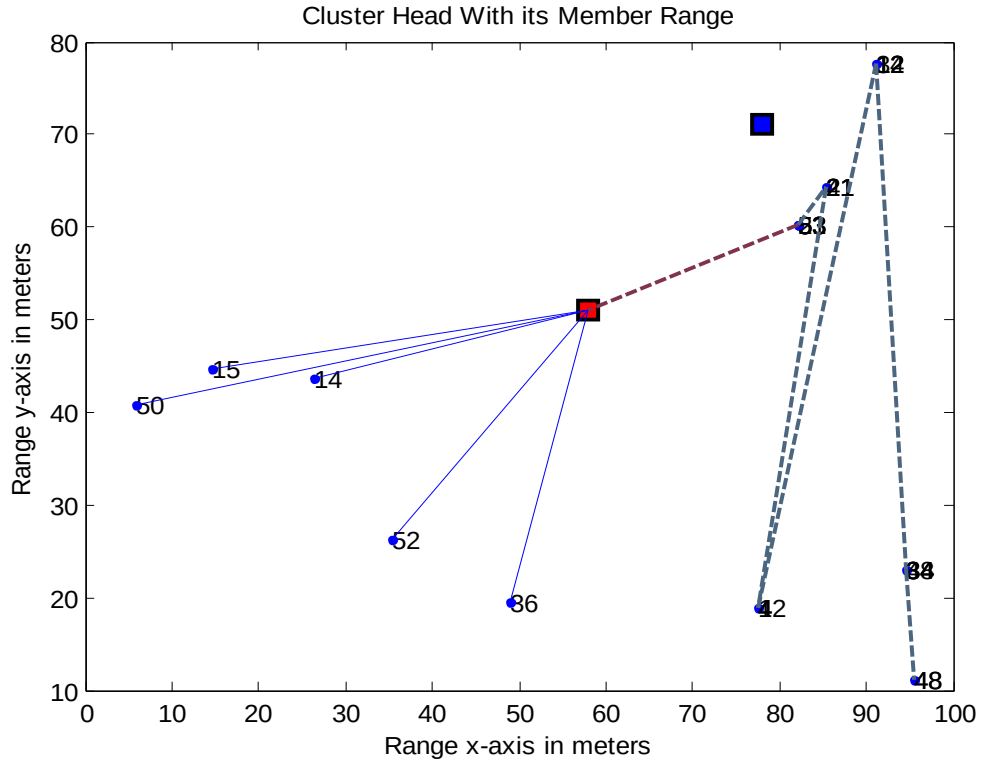

Figure 4.10 (Cluster-3) Nearest uncovered node forwards all the uncovered node to CH

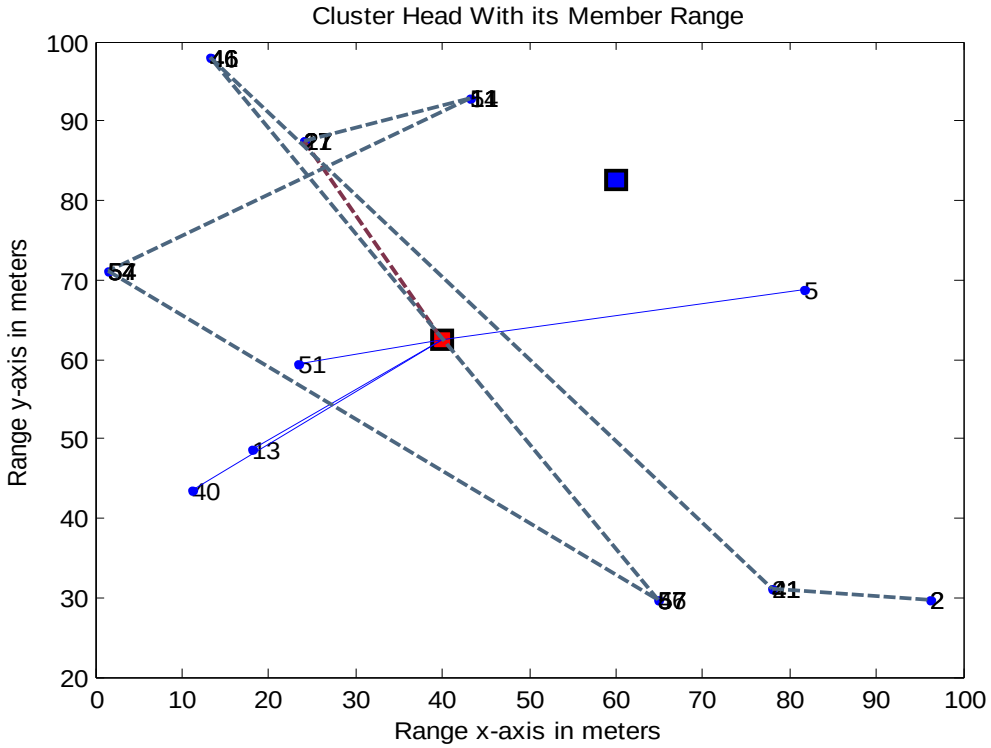

Figure 4.11 (Cluster-4) Nearest uncovered node forwards all the uncovered node to CH

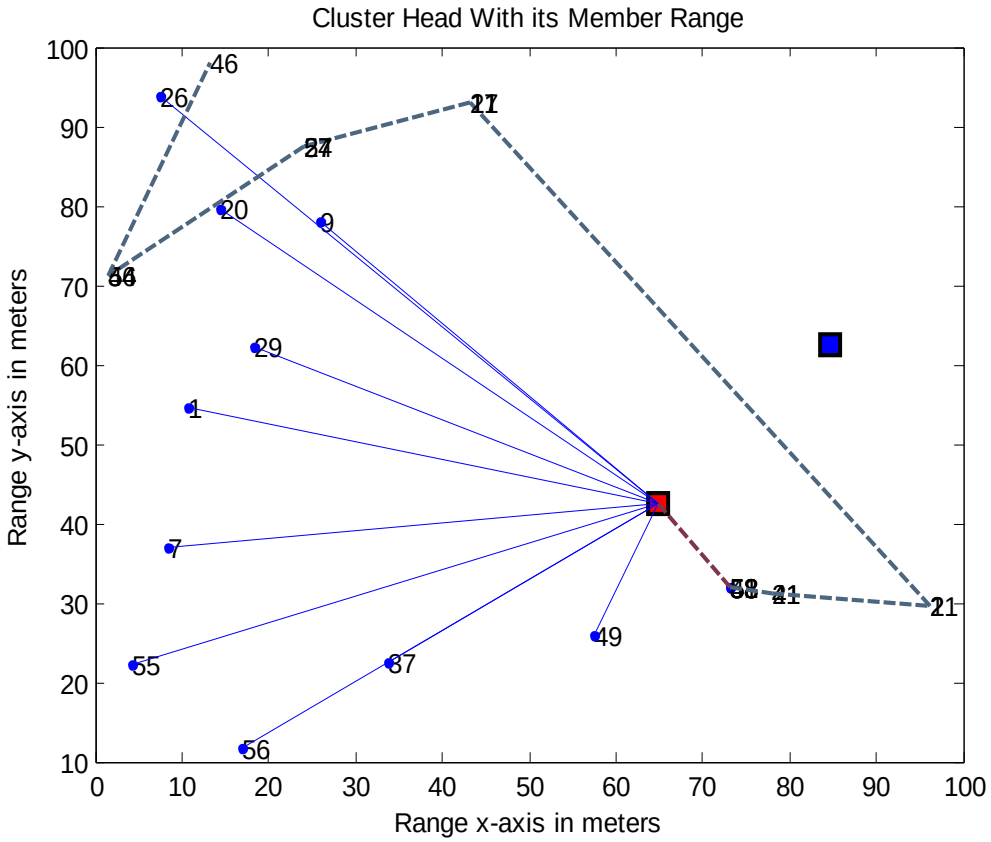

Figure 4.13 (Cluster-5) Nearest uncovered node forwards all the uncovered node to CH

Step 4: In case the sensor nodes die rate will exceeded the threshold value then BACKUP set is activated and the old technique will works again i.e. backup set collects all uncovered nodes and forward them to their respective cluster head and in case any cluster head fails due to extra work load or any other power related issue then backup set calculates the remaining residual energy of member sensor nodes and the node with highest residual energy becomes the cluster head of that particular cluster. Figure 4.12, 4.13, 4.14, 4.15, 4.16 shows the BACK up set will activated when the threshold value of sensor node die rate is exceeded the value of threshold level adjusted by user. Die rate of sensor node is based upon the sensor node die with the increase in number of rounds.

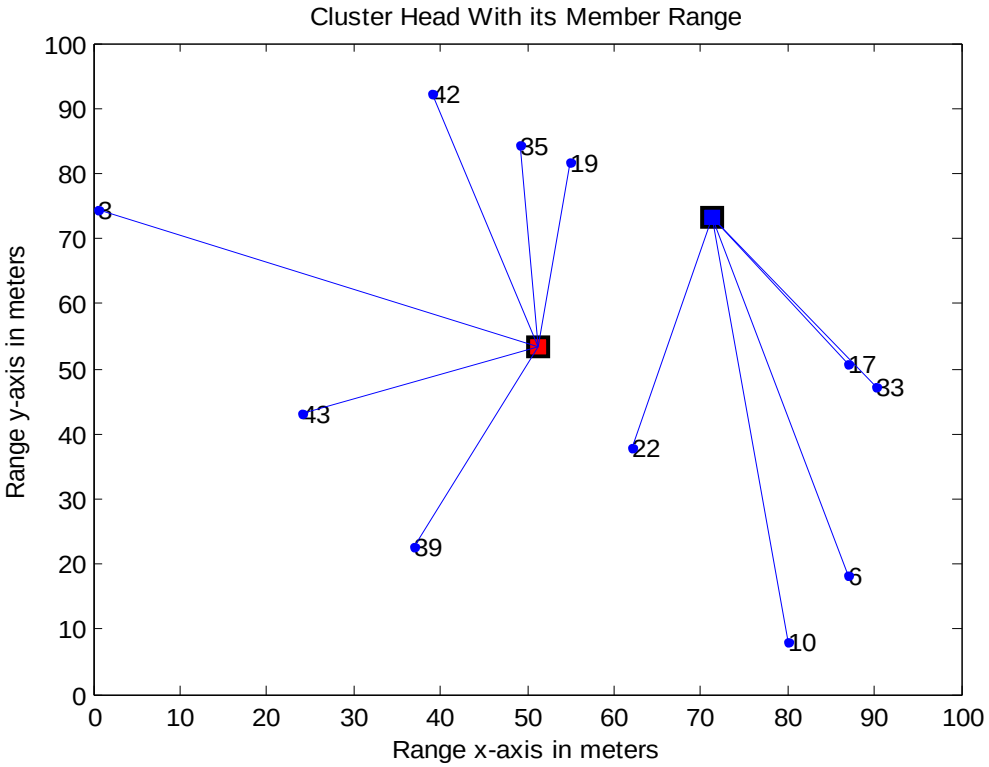

Figure 4.14 (Cluster-1) Back up set collects all uncovered nodes and forwards to CH

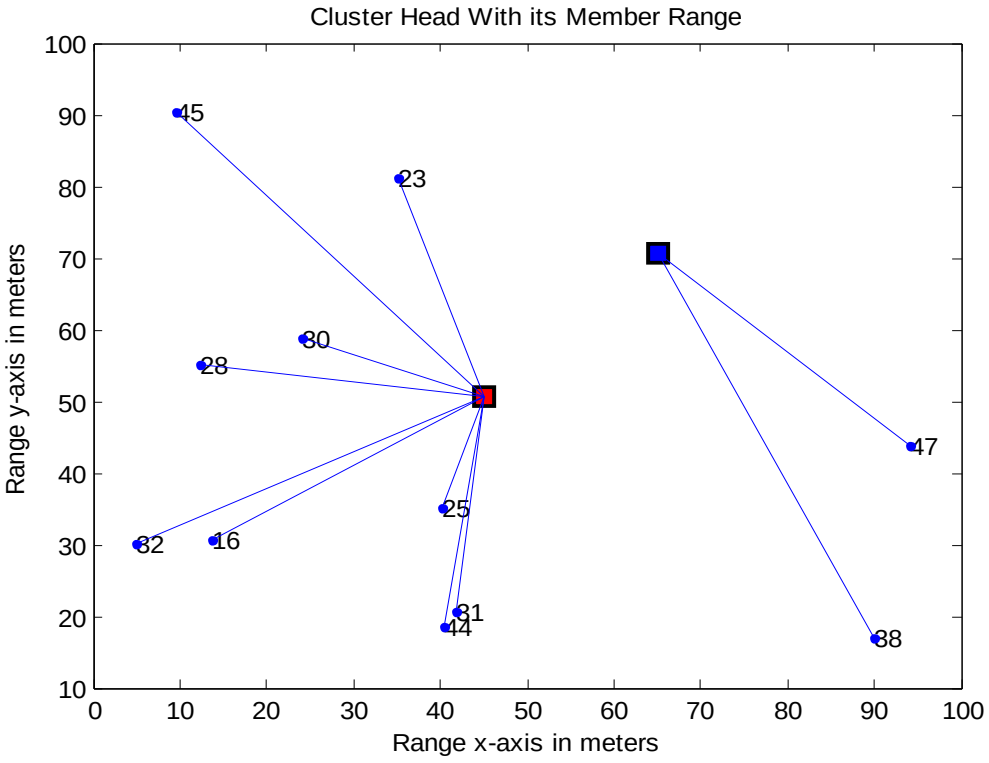

Figure 4.14 (Cluster-2) Back up set collects all uncovered nodes and forwards to CH

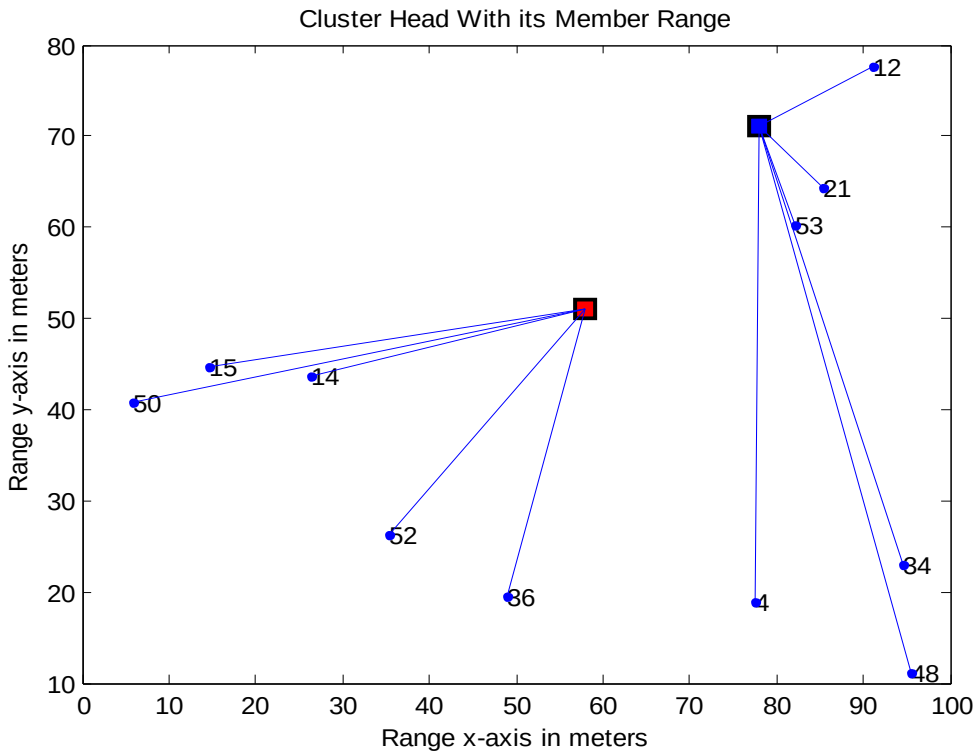

Figure 4.15 (Cluster-3) Back up set collects all uncovered nodes and forwards to CH

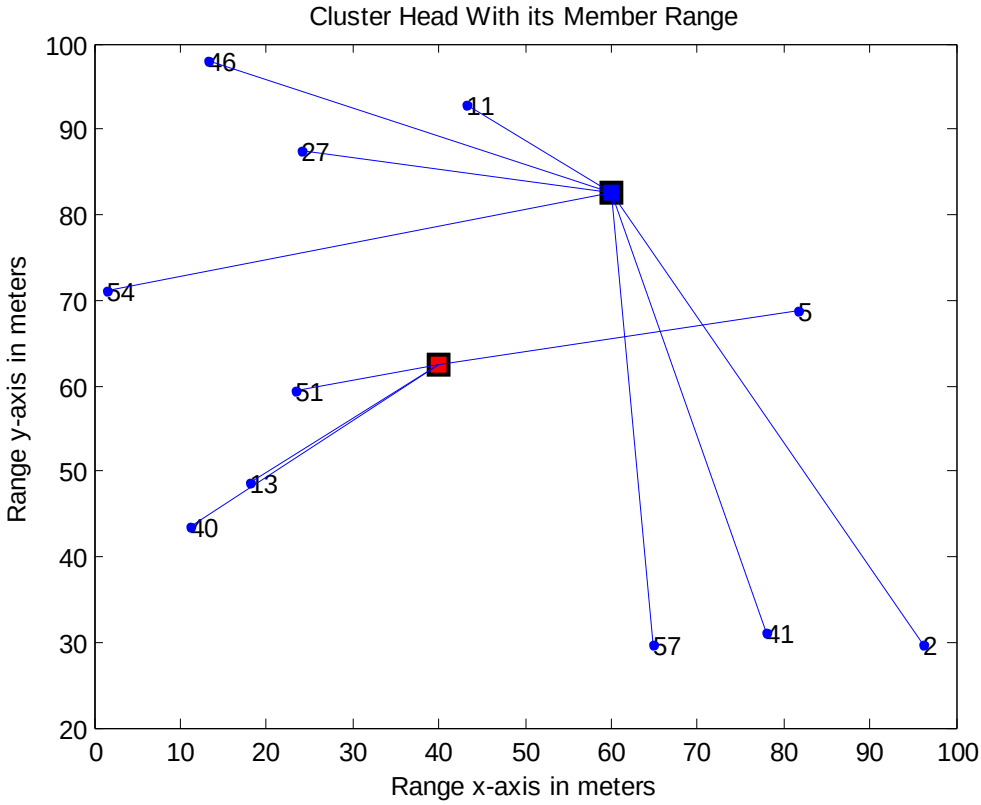

Figure 4.16 (Cluster-4) Back up set collects all uncovered nodes and forwards to CH

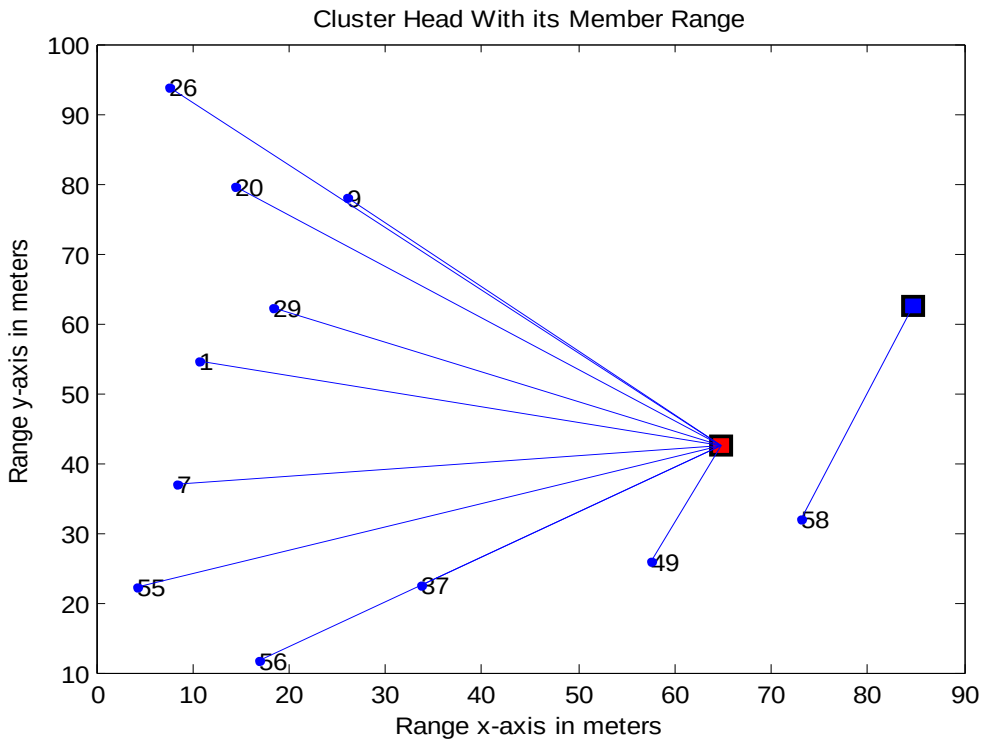

Figure 4.17 (Cluster-5) Back up set collects all uncovered nodes and forwards to CH

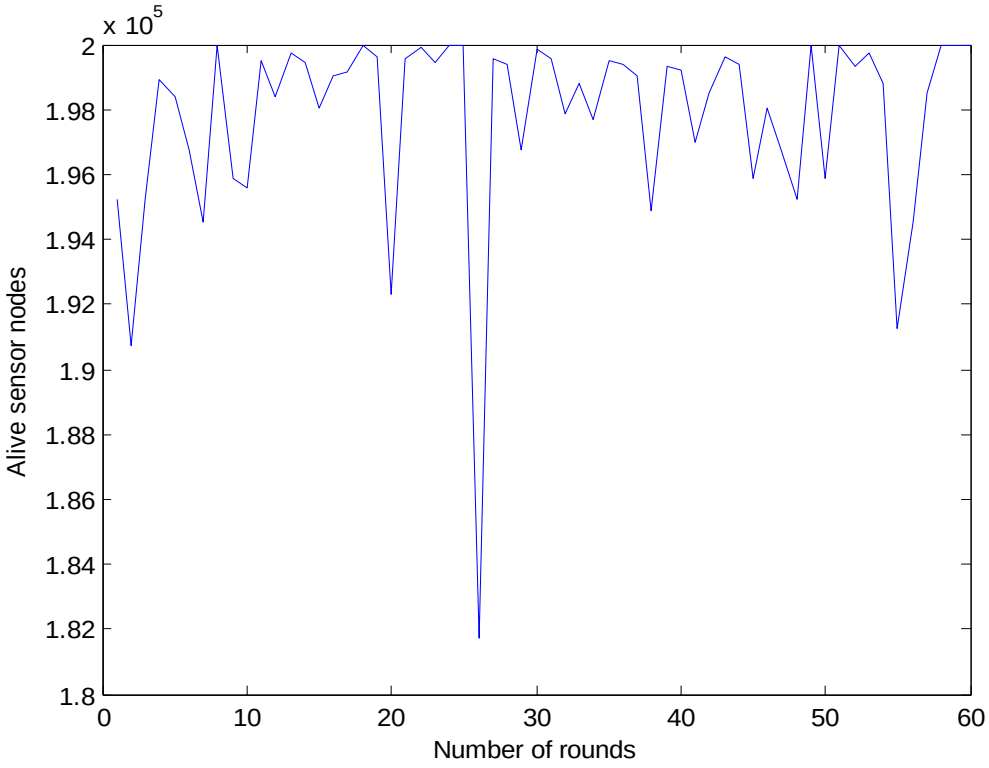

Figure 4.18 Each sensor node has initial energy of 2 joules and for each gateway(CH) initial energy is 10joules. A node is considered dead if its energy level reaches to 0 joules.

4.2 Comparision Of Results With DFCA algorithm

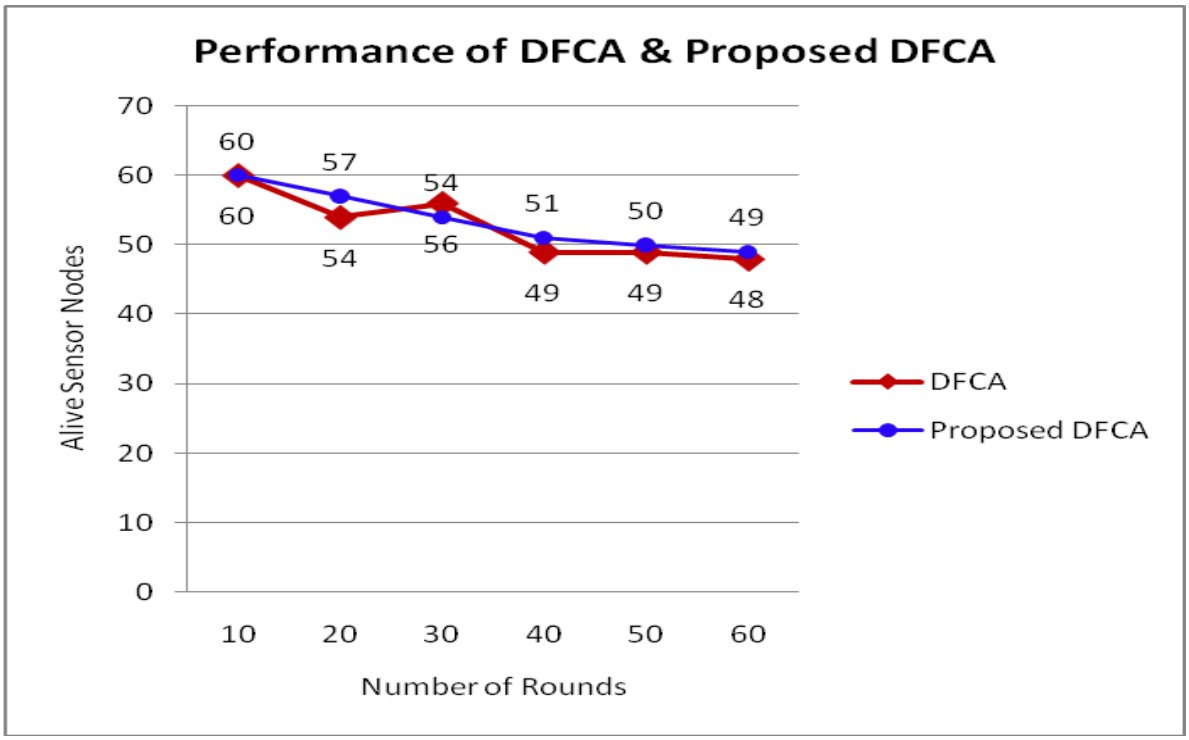

Figure 4.19 Results comparision with DFCA algorithm

- When this proposed algorithm is applied at 60 number of rounds then only the 11 nodes are dies but in DFCA algorithm 12 to 15 sensor nodes are die at the 60th round so the new algorithm shows good results.
- We take tests on rounds 10, 20, 30, 40, 50, 60.
- The results of these tests showed that less number of sensor nodes and cluster dies in decrease in energy increases with the no of rounds.

CHAPTER 5

Summary and Conclusions:

In my research base paper author propose an algorithm named as DFCA (a distributed fault tolerant clustering algorithm) which uses a cost function of CH. For putting forth group in defense of sudden disappointment of CH and it gives go down set and move down hub which will dynamic amid the bunch disappointment by figuring the remaining vitality of part sensor nodes and make the hub CH with most astounding lingering vitality. the sensor nodes consume more energy due to extra energy based issues or work load this is the major reason failure of cluster heads for preventing network from sudden failure back up node or back up set will provided along with the network because it will not stop the whole network in case of cluster head failure.

It will focus on the suitable cluster formation [6] and error tolerance [5] apparatus for this the DFCA (a distributed fault tolerant clustering algorithm) algorithm is used which uses a cost function of CH. For presenting cluster in defense of sudden disappointment of CH and it gives go down set and move down more sensor nodes which will dynamic amid the overall communication failure disappointment. This go down set fundamentally gathers the unattended sensor nodes and unite them with the primary cluster head. What's more, in case if the cluster head fizzles it gathers the vitality thought starting the other part sensor nodes and make the node group head which have staying most residual remaining vitality.

But everything comes with a disadvantage in my research work, improved some disadvantages of DFCA as per at the beginning there is no requirement of backup set so in my work I removed the backup set at a beginning phase or first rounds we implemented a algorithm in which uncovered node is nearest to CH will first collects all the other member uncovered nodes then it will be forward to their respective CH. And on the basis of sensor node die a threshold value will be given in algorithm when number of sensor node die rate is increases that threshold level then the backup set will activated which collects all uncovered nodes and forward them to their respective cluster head.

Chapter 6

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[9] Gupta G. and Younis M., "Load-balanced clustering of wireless sensor networks," ICC '03, IEEE International Conference, vol. 3, pp. 1848- 1852, 2003.

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